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MODEL HO-1

HETERODYNE MIXER-OSCILLATOR

INSTRUCTION MANUAL

WEINSCHEL ENGINEERING

GAITHERSBURG, MARYLAND

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105/cA1608

MODEL HO-1
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INSTRUCTION MANUAL

DESIGNERS AND MANUFACTURERS OF PRECISION MICROWAVE EQUIPMENT

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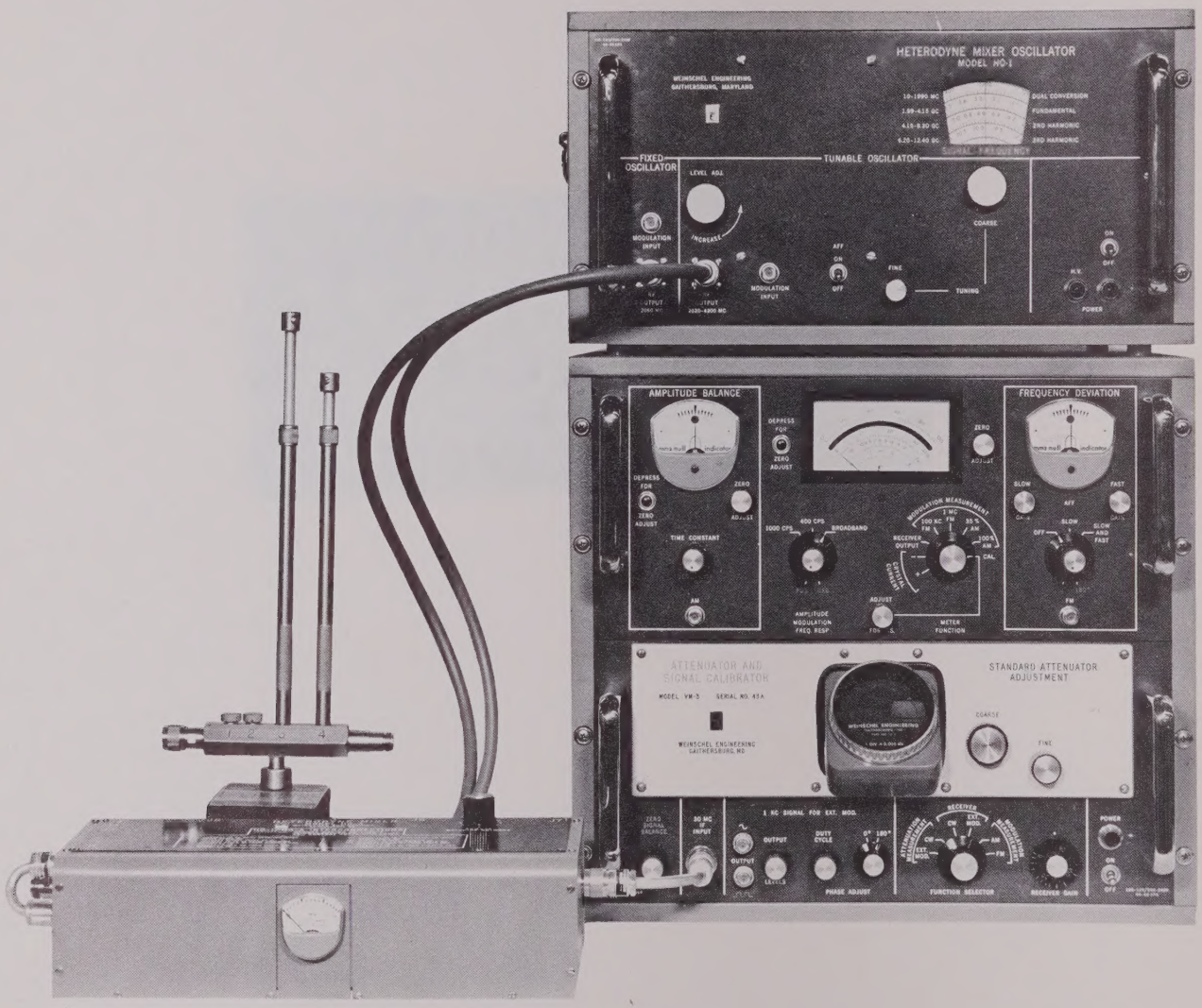

Frontispiece. HO-1/VM-3 System

MODEL HO-1 HETERODYNE MIXER-OSCILLATOR

INSTRUCTION MANUAL CORRECTIONS

1. Page 5-15, paragraph 5.4.4,, step 4. Last word in sentence should read powermeter, not voltmeter.

2. Page 5-17, paragraph 5.4.5, step 3. First sentence should read: "Adjust the probe depths for an RF power output of approximately 2 milliwatts maximum output from the source." Not "as indicated on the RF power meter." Add: "Take care not to screw the probe into the klystron."

PARTS CHANGES

Page 6-1. Change F101 from 2A to 1A.

Change F102 from 3A to 2A.

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MODEL HO-1

HETERODYNE MIXER-OSCILLATOR

INSTRUCTION MANUAL

SECTION I

INTRODUCTION

1.1 SCOPE OF MANUAL

This manual covers the description, specifications, theory of operation, operating instructions, maintenance, and parts list for the Model HO-1 Heterodyne Mixer-Oscillator and associated equipment manufactured by Weinschel Engineering Company, Inc., Gaithersburg, Maryland. A photograph of the Model HO-1 connected to the Model VM-3 Attenuator and Signal Calibrator is shown in the frontispiece, page ii. For specific topics, refer to the Table of Contents, page iii.

1.2 PURPOSE OF EQUIPMENT

The Weinschel Engineering Model HO-1 Harmonic Mixer-Oscillator provides a complete local oscillator-mixer system for the heterodyne conversion to 30 mc of signals in the frequency range from 10 mc to 12.4 gc. The Model HO-1 oscillator module, together with the Model HO-A Mixer package and the Model DS-109 Double Stub Tuner - supplied as accessories - were designed to be used with the Weinschel Model VM-3 Attenuator and Signal Calibrator, the Weinschel Model VM-1 Standard Attenuator Comparator, and similar heterodyne receivers operating at 30 mc. Use of the HO-1 eliminates the need for 6 or 7 local oscillators with associated power supplies and mixers.

The Model HO-1 is ideally suited to general laboratory, standards laboratory, and field applications where ruggedness, high sensitivity, broadband operation and accuracy are important.

1.3 SYSTEM SPECIFICATIONS.

Table 1-1

Specification	Descriptive Data
Signal Frequency Range:	10 mc to 12.4 gc
IF Output Frequency	30 mc
Smallest Usable RF Signal: (Read on VM-3)	10 to 1990 mc: -100 dbm 1990 to 4150 mc: -110 dbm 4150 to 8300 mc: -100 dbm 6200 to 12,400 mc: -100 dbm
Dynamic Range: *	10 to 1990 mc: 85 db (Double Conversion 1990 to 4150 mc: 95 db (Fundamental mixing) 4150 to 8300 mc: 85 db (2nd Harmonic mixing) 6200 to 12,400 mc: 80 db (3rd. Harmonic mixing)
Maximum RF Input Level:	10 mc to 12.4 gc: -10 dbm
Output RF Connectors	Type N
AFF:	Input signal jack on back of chassis (Amphenol #22-11S)
Modulation:	Input BNC jacks to both oscillators for repeller modulation using external signal.
Power Requirements	115V/230V; 50/60 cps; approximately 175 w
Equipment Supplied:	One Model HO-1 Heterodyne Mixer-Oscillator (including cabinet) One Model HO-A Heterodyne Mixer One Model DS-109 Double Stub Tuner Two Type RG-9/U interconnecting cable assemblies Two interconnecting IF cable assemblies One 115V/230V AC power cable One AFF cable assembly One Instruction Manual - Model HO-1
Size and Weight: Model HO-1 Model HO-A Model DS-109	 21" W x 10" H x 15-1/2 D - approximately 57 lbs. (including cabinet) 6-3/4 W x 5-1/4 H x 16" L - approximately 17 lbs. 6-1/8" W x 20-3/4" H x 3-1/4" L - 5 lbs.

* .5 db maximum measurement error, using VM-3, due to effect of mixer nonlinearity and noise.

Table 1-1 Cont'd.

HO-1 TUNABLE OSCILLATOR:

NOTE

The Tunable Oscillator frequency (f_o) is related to the SIGNAL FREQUENCY dial calibration as follows:

f_o = DUAL CONVERSION scale +2090 mc;

f_o = FUNDAMENTAL scale +30 mc;

$f_o = \frac{\text{2ND HARMONIC scale +30 mc}}{2}$;

$f_o = \frac{\text{3RD HARMONIC scale +30 mc}}{3}$.

Specification	Descriptive Data
Frequency Range	2020 - 4200 mc
Accuracy of Tunable Oscillator Frequency as related to SIGNAL FREQUENCY dial indication.	1%
Dial Resetability	±0.5%
Dial Backlash Error	Less than 0.5%
Frequency change with 10% Change in AC Line Voltage	Less than .02%
Frequency Modulation (cw)	Less than 20 kc
RF Power Output: (continuously variable) Maximum cw output: 100% Square Wave Modulated: (average power)	 5 mw min. from 2020 to 2090 mc 15 mw min. from 2090 mc to 4200 mc 2.5 mw min. from 2020 to 2090 mc 7.5 mw min. from 2090 mc to 4200 mc
RF Power Output Stability (after initial one hour warmup period)	long term: 0.1 db/hr. short term: less than 0.02 db/2 min.
RF Power Output Change with 10% change in AC Line Voltage	Less than 2.5%

Table 1-1 Cont'd.

Specification	Descriptive Data
Repeller Modulation Sensitivity	250 kc/V approx.
External Modulation Frequency	400 to 4000 cps
External Modulation Amplitude	10V - 45V P-P

HO-1 FIXED OSCILLATOR

Specification	Descriptive Data
Frequency	2060 mc ± 0.15%
Frequency Change with 10% change in AC line voltage	Less than 0.02%
Frequency Modulation (cw)	Less than 10 kc
RF Power Output:	
Change in 10% line voltage variation:	2.5%
Maximum cw power (fixed)	5 mw minimum
100% Square-wave modulated: (average power)	2.5 mw minimum
Stability (after initial one-hour warm-up period)	long term: less than 0.1 db/hr short term: less than .02 db/2 min.
Repeller Modulation Sensitivity	100 kc/V approx.
External Modulation Frequency	400 - 4000 cps
External Modulation Amplitude	.5 - 12V P-P

1.4 DESCRIPTION.

1.4.1 Mechanical. The Model HO-1 oscillator module is supplied with its own cabinet. With the cabinet removed, the unit may be mounted in a standard 19" relay rack.

The microwave oscillators and tuning mechanism are mounted in an aluminum casting which is removable as a unit for maintenance purposes. The oscillators are forced-air cooled by an internal shock-mounted fan.

The Model HO-A Mixer module is supplied with a removable outer cover which exposes the mixer circuitry for component adjustment and maintenance.

1.4.2 Electrical. The Model HO-1 oscillator module contains two microwave oscillators together with their associated power supplies. Two oscillators are required for dual conversion in the signal frequency band from 10 mc to 1990 mc. The first oscillator is tunable from 2020 mc to 4200 mc, while the second operates at a fixed frequency of 2060 mc. From 1990 to 4150 mc fundamental mixing is employed, and from 4150 to 12,400 mc second and third harmonic mixing is used. The direct-reading dial is calibrated for SIGNAL FREQUENCY operations in the fundamental, harmonic, and dual conversion modes. Only one knob is needed for tuning the signal frequency; all voltages are automatically tracked.

The HO-A Mixer module is supplied as part of the HO-1 system, and is connected to the HO-1 oscillator module by means of cables which are provided. The HO-A contains the necessary directional couplers, filters, and diode mixers to convert an external signal to a 30-mc IF over the full frequency range from 10 mc to 12.4 gc. External signal sources must provide at least -10 dbm output available at the HO-A input to use the full dynamic range of the receiver.

1.4.2.1 Dual Conversion Operation. Frequency conversion to 30 mc of a signal between 10 and 1990 mc is obtained by using two mixers. The first mixer uses the difference between the tunable oscillator of the HO-1 and the RF signal to obtain a first IF signal at 2090 mc. A sharply tuned filter between the first and second mixers suppresses any mixer products other than the desired 2090-mc first IF signal. The second mixer uses the 2060-mc fixed oscillator signal to convert the 2090-mc IF signal down to 30 mc.

1.4.2.2 Fundamental and Harmonic Mixing. In the frequency range from 1990 to 12,400 mc, the RF signal and the tunable oscillator of the HO-1 are connected to the second mixer only, which consists of an 8.5-db directional couple and a tunnel diode. For harmonic mixing, the oscillator signal level is adjusted to generate second and third harmonics in the tunnel diode strong enough to assure linear conversion to 30 mc.

An AFF (automatic frequency follower) input is provided in the HO-1 to lock the tunable oscillator frequency or its harmonic to a 30-mc difference from the signal frequency. The AFF correction voltage is produced in the receiver.

1.4.3 Operating Controls, Indicators, and Connectors. All operating controls, indicators, and connectors are readily accessible, and are listed and described in table 1-2.

Table 1-2

MODEL HO-1 CONTROLS, INDICATORS, AND CONNECTORS

Item	Description and Function
HO-1 Front Panel:	
SIGNAL FREQUENCY dial	The main tuning dial for the HO-1 tunable oscillator, calibrated directly in signal frequency in four modes: DUAL CONVERSION, FUNDAMENTAL, 2ND HARMONIC and 3RD HARMONIC.
COARSE TUNING control	Tunes the frequency of the tunable oscillator compatible with the signal frequency as indicated on the SIGNAL FREQUENCY dial.
FINE TUNING control	Fine-tunes the frequency of the tunable oscillator
AFF ON-OFF switch	A two-position toggle switch that opens or closes the AFF feedback loop.
MODULATION INPUT (Tunable Oscillator) (J103)	A BNC connector for injection of an external modulation voltage to the repeller of the tunable oscillator.
RF OUTPUT 2020-4200 mc (J101)	Type N female connector.
LEVEL ADJ. control	Adjust the RF output power level of the tunable oscillator.
MODULATION INPUT (FIXED OSCILLATOR)(J104)	A BNC connector for injection of an external modulation voltage to the repeller of the fixed oscillator.
RF OUT (2060 mc) (J102)	Type N female connector.
POWER switch	A two-position toggle switch which controls the application of AC power to the HO-1.
Green POWER lamp	Comes on when AC power is applied to the HO-1.
Red H.V. POWER lamp	Comes on when the thermal time delay relay closes and high voltage is applied to the oscillators.

Table 1-2 Cont'd.

HO-1 Rear Apron:

AFF OUT connector, J105	A shielded two-connector high-voltage jack allowing application of the AFF voltage from the receiver.
POWER connector, P-101	A standard recessed male grounded plug for application of AC power to the HO-1.
Fuse F-101	A 2A fuse in the primary of the high-voltage power supply transformer.
Fuse F-102	A 3A fuse in one side of the AC power line.
R 135	A potentiometer used for fine tuning of frequency of fixed oscillator.
R 114	A 50K potentiometer used for klystron repeller voltage supply adjustment.

HO-A Mixer Module:

DIODE MIXER CURRENT I_1 meter, M-1	A 0-3 milliameter used to monitor the current drawn by the first mixer diode.
30 mc IF MATCHING NETWORK switch	An 11-position step switch used to vary the series inductance of the 30-mc IF matching network.
J1 thru J7	Type N connectors used as the various signal input and output sources in various configurations. Their use is described in Section IV, Operating Instructions.

1.4.4 Internal Adjustments. Certain screwdriver-adjust controls are located within the equipment mounted on the HO-1 main chassis. Since these controls are used only when specifications compliance tests are made, they will be referenced in the Maintenance Section of this manual.

1.4.5 Equipment Supplied. The following equipment is supplied with the HO-1:

One Model HO-1 Heterodyne Mixer-Oscillator (including cabinet)
One Model HO-A Heterodyne Mixer
One Model DS-109 Double Stub Tuner
Two Type RG-9/U interconnecting cable assemblies
Two interconnecting IF cable assemblies
One 115V/230V AC power cable
One AFF cable assembly
One Instruction Manual - Model HO-1

The AFF cable assembly is supplied with an HO-1 mating connector on one end and a VM-3 AFF mating connector on the other. If a receiver other than the VM-3 is used, the VM-3 AFF plug should be removed and the appropriate mating connector installed in its place.

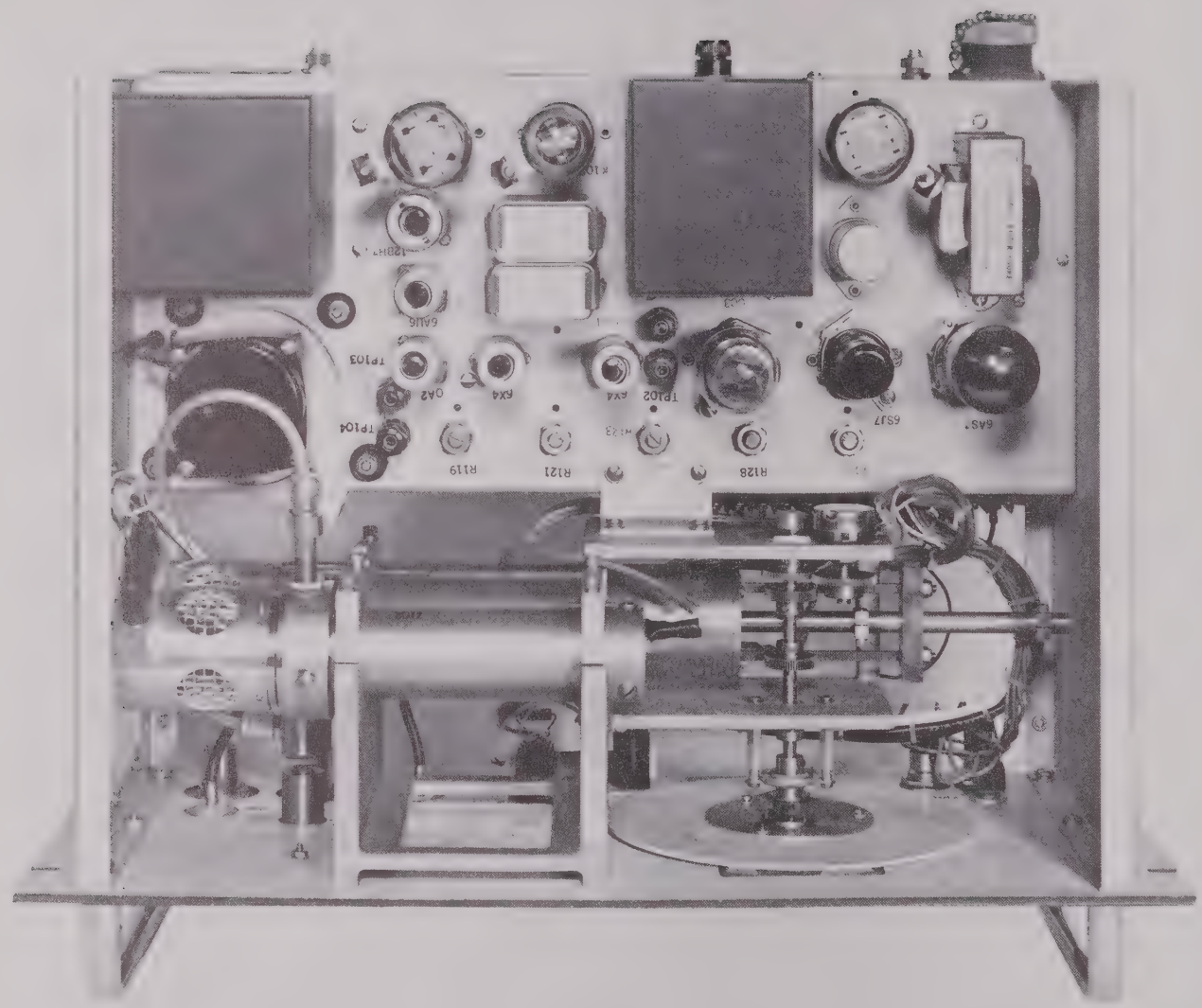

Figure 1.1. HO-1 Oscillator Module, Top View

SECTION 2

THEORY OF OPERATION

2.1 GENERAL THEORY

The Model HO-1 Heterodyne Mixer-Oscillator is a complete local-oscillator-mixer system for the heterodyne conversion to 30 mc of signals in the frequency range from 10 mc to 12.4 gc. The HO-1 is supplied with an accessory Model DS-109 Double-Stub Tuner for impedance matching above 1000 mc, and operates in conjunction with the Model VM-3 Signal Generator Calibrator or similar 30-mc receivers to constitute a complete broad-band receiving system.

The use of linear RF mixing techniques as applied to attenuation and signal measurements is described in "Relative Voltmeter for VHF/UHF Signal Generator Calibration" by B. O. Weinschel, G. U. Sorger, and A. L. Hedrich (IRE Transactions on Instrumentation, Vol. I-8, No. 3, March, 1959).

The HO-1 is housed in two cabinets: the HO-1 Oscillator Module and the Model HO-A Mixer Module. Two separate oscillators, one tunable from 2020 to 4200 mc, and the other fixed at 2060, are contained in the first cabinet, together with the necessary power supplies. The second cabinet contains the first and second diode mixers and associated circuitry.

The HO-1 Heterodyne Mixer Oscillator operates in four different conversion modes to generate the 30-mc IF signal to the receiver:

2.1.1 DUAL CONVERSION Mode. Frequency conversion to 30 mc of a signal between 10 and 1990 mc is obtained by using two mixers. The first mixer uses the difference between the tunable oscillator of the HO-1 and the RF signal to obtain a first IF signal at 2090 mc. A sharply tuned filter between the first and second mixers suppresses mixer products other than the IF signal. The second mixer uses the 2060-mc fixed oscillator signal to convert the 2090-mc first IF signal to 30 mc, the second IF signal.

2.1.2 FUNDAMENTAL Mode. The tunable oscillator is used as LO in its fundamental frequency range. The tunable oscillator output is connected directly to the second mixer and the first mixer is not used. The RF signal is therefore mixed with the oscillator fundamental frequency for direct linear conversion to 30 mc.

2.1.3 HARMONIC Modes. In the detection of frequencies above 4150 mc, the HO-1 is interconnected as in the FUNDAMENTAL mode, and the double-stub tuner is used at the signal input. The tunable oscillator signal level is adjusted to produce within the tunnel diode second and third harmonics of the fundamental LO signal of sufficient strength for linear conversion of incoming signal frequencies to 30 mc.

2.1.4 Image Frequency Response. As in any heterodyne receiver system, image frequencies are present in the HO-1 system. Signal detection occurs when the tunable oscillator frequency or its harmonic is above the signal frequency by 30 mc in the FUNDAMENTAL or HARMONIC modes and 2090 mc above the signal frequency in the DUAL CONVERSION mode. The tunable oscillator is designed to operate on the high side of the signal frequency as reflected in the SIGNAL FREQUENCY dial calibration.

Image response will be found in the FUNDAMENTAL and HARMONIC modes at a

dial indication 60 mc below the actual signal input frequency. Operation of the HO-1 system at the image frequency will in no way degrade system performance. However, operation at image frequencies will require reversal of the AFF phase by 180° for capture of the input signal.

The 2090-mc first IF used in the DUAL CONVERSION mode precludes the existence of image frequencies within the bandpass of the system.

Because of the selection of the first IF at 2090 mc, a strong signal will be detected when the SIGNAL FREQUENCY dial is set at 0 on the DUAL CONVERSION scale, which corresponds to an actual frequency of the tunable oscillator of 2090 mc. This passes through the 2090-mc circuitry unimpeded to mix with the 2060-mc fixed oscillator signal with a resultant strong 30-mc input signal to the receiver. While this signal falls just outside the DUAL CONVERSION band, it can be used very effectively to aid in properly adjusting and setting the HO-1 signal FREQUENCY dial, and evaluate spurious responses if they ever occur.

2.2 HO-1 OSCILLATOR MODULE.

Figure 2.1 is a block diagram of the HO-1 oscillator module.

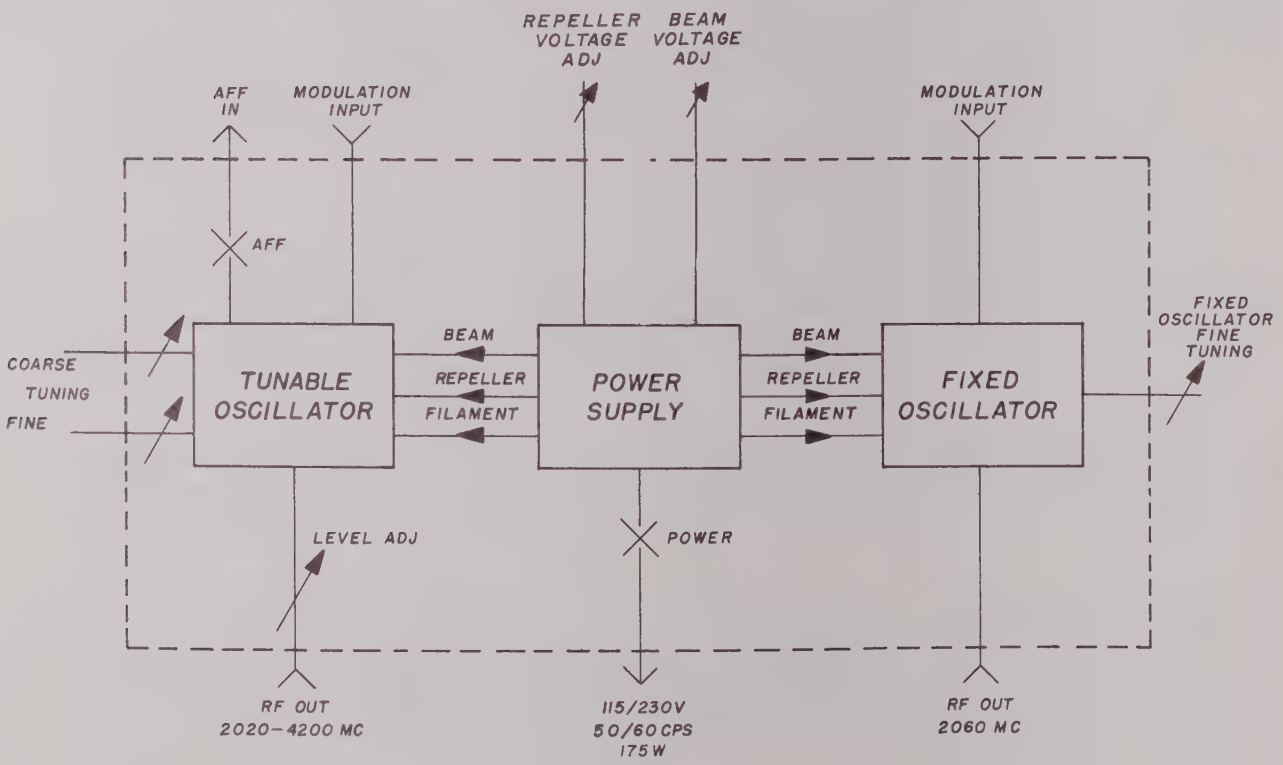

Figure 2.1. HO-1 Oscillator Module, Block Diagram

2.2.1 Tunable Oscillator. The tunable oscillator consists of type 6BL6 reflex klystron mounted in a shorted coaxial-type resonator operating in the 3/4-wavelength mode. The shorting plunger is of the non-contacting Z-type, known for its high rear cavity power loss and its wide frequency range. The klystron operates in the 2-3/4 mode from 2020 mc to 4200 mc. The SIGNAL FREQUENCY dial is directly

calibrated in the frequency of the RF signal in all four modes with the tunable oscillator fundamental frequency or harmonics operating on the high side of the signal frequency.

Oscillator frequency is adjusted by the COARSE TUNING control which actuates a precision machined rack-and-gear drive to move the short-circuit plunger. Mounted to rotate with the dial is the tracking control, R-118, a potentiometer that provides the proper repeller voltage for each frequency setting. The FINE TUNING control, R-122, optimizes the repeller voltage for maximum power output.

The cavity is precisely machined and honed from a heavy casting, and is cradled in a rigid cast aluminum bed. This solid construction permits frequency stability unattainable in lighter equipment.

The tunable oscillator may be AM or FM modulated by applying the proper modulation function to the MODULATION INPUT connector on the front panel. The modulation signal may be supplied by an external modulator or the VM-3 receiver.

The LEVEL ADJ. control adjusts the RF output by means of a movable probe within the cavity. Output is taken from the RF OUTPUT 2020-4200 mc type N connector on the front panel.

Frequency of the tunable oscillator is controllable within prescribed limits by an external Automatic Frequency Follower signal. The AFF signal is fed to the oscillator control circuitry at the AFF receptacle, J-105, on the rear apron of the chassis.

2.2.1.1 Automatic Frequency Follower Circuitry. To compensate for the effects of frequency drift and incidental FM of the 30 mc difference frequency between the tunable oscillator and the signal source, an interdependent automatic frequency follower circuit exists between the HO-1 tunable oscillator and the Model VM-3 receiver. The VM-3 receiver will produce a voltage proportional to the frequency difference between the IF and the 30-mc standard source within the VM-3. This voltage is fed through the AFF cable into the repeller of the tunable oscillator. With the feedback loop closed, this correction voltage will change the repeller voltage of the tunable oscillator which in turn changes the frequency of the tunable oscillator to maintain equality between the IF and the 30-mc reference source within the VM-3.

The final DC amplifier stage of the VM-3 AFF feedback amplifier acts as a variable resistance thereby varying the tunable oscillator repeller voltage. With the AFF switch ON, this tube is connected into the repeller circuit. With the AFF switch OFF, an 82K resistance is substituted for the tube with zero correction voltage applied. Since the resistance of the tube at zero correction voltage depends slightly on the actual repeller voltage, it is sometimes necessary to re-adjust the equalizer control on the rear apron of the VM-3 to make the tube resistance equal to 82K.

Theory of operation of the AFF circuitry in the VM-3 is found in paragraph 4.10 on page 43 of the VM-3 Instruction Manual.

The AFF action serves two purposes:

a. to prevent a drifting of the HO-1 30-mc IF from the 30-mc reference source within the VM-3,

Signal input between 10 and 1990 mc is combined in the first mixer circuitry with the 2020 to 4200-mc tunable oscillator output of the HO-1. First IF output is at 2090 mc.

The first IF signal is combined in the second mixer circuitry with the 2060-mc output of the HO-1 fixed oscillator. Second IF output to the receiver is at 30 mc.

For signal frequencies between 1990 mc and 12.4 gc, single conversion fundamental or harmonic mixing is used; both the signal and the output of the HO-1 tunable oscillator are coupled directly to the second mixer circuitry, and the resultant 30-mc output introduced to the receiver.

The Half-Wave Reaction Cavity is a half-wave trap at the first IF frequency, and acts to reflect the proper impedance interface to the input of the first mixer diode and prevent the loss of IF signal energy toward the signal source. This circuit has negligible effect on any input signal frequency from 10 to 1990 mc.

The Current Monitor Tee is used to pick off the rectified DC diode current resulting from LO injection to the first mixer diode. The magnitude of the current is about proportional to the LO power. This current is designated I_1 and indicated on M-1, the 0-3 milliameter mounted on the side of the mixer module. The Tee comprises a DC blocking capacitor in the RF signal path and a DC current tap in shunt with the center conductor. The tap presents a high RF impedance to signals from 10 to 2000 mc present in the main line.

The 10-db Directional Coupler is used to combine the RF signal and the LO signal from the tunable oscillator. The coupler has sufficient RF directivity to prevent the loss of signal energy into the LO channel; coupling loss between the tunable oscillator output and the mixer is on the order of 10 db.

The First Diode Mixer consists of a tunnel diode assembly made in the form of a coupling loop magnetically coupled to the input cavity of the 2090-mc multisection cavity. The diode linearly converts the 10-to-1990-mc input signal to a first IF of 2090 mc as required for dual conversion operation (using the tunable oscillator as first LO). Linear mixing action occurs when the first diode mixer current I_1 is 1.75 to 1.85 ma as monitored on meter M1, and the RF signal level is below -15 dbm.

The Multisection Cavity is a narrow-band filter which determines the 2090-mc IF bandpass selectivity. Because the lowest RF signal frequency is 10 mc, the multisection cavity filter must be sharp enough to reject the image frequency which is only 20 mc away from the first IF.

The 2200-mc-Low Pass Filter effectively rejects any frequency above 2200 mc and prevents overtone leakage into the second mixer.

The 2090-mc Tuner is used to peak the 2090-mc first IF signal and optimize power transfer to the second mixer.

The 8.5-db Directional Coupler is used to combine the RF signal and the LO signal from either the tunable or fixed oscillator. The coupler has sufficient RF directivity to prevent the loss of signal energy into the LO channel; coupling loss between the LO output and the mixer is on the order of 8.5 db.

The Second Diode Mixer mount contains a tunnel diode that linearly converts RF signals between 1990 mc and 12.4 gc to 30 mc as required in all operating modes of the HO-1 system. In the dual conversion mode, the RF signal is always at 2090 mc, and the fixed 2060-mc oscillator is used as LO. In the fundamental and harmonic modes, the tunable oscillator is used as LO. Linear mixing action occurs when the second diode mixer current I_2, monitored on the VM-3 main meter, is 0.75 to 0.85 ma during dual conversion and fundamental operation, and 2.0 to 2.2 ma during harmonic operation, and the RF signal level is below - 15 dbm. For a detailed discussion of diode mixer theory, the following reference is suggested: "Microwave Mixers," Pound, Vol. 16, Radiation Laboratory Series, McGraw-Hill, New York. For a discussion of harmonic mixing theory, see "Investigation of Precision Antenna Pattern Recording and Display Techniques," J. B. Chastain et al, Scientific-Atlanta, Inc., 3rd. Qtrly Report 62, Rome Air Development Ctr.

The 30-mc IF Matching Network consists of a series inductance which can be varied in steps between about .2 microhenry and 1.5 microhenries. Together with the tuning capacitance contained in the VM-3, it forms an L-type impedance transformer to optimize power transfer between the low output impedance of the second diode mixer and the input impedance of the VM-3.

If receivers without tuning capability are used, the series inductance in the HO-A can be made approximately zero by turning the control fully counterclockwise.

The DIODE CURRENT I_1 Meter provides visual monitoring of the first diode mixer current. It is a 0-3 milliameter.

2.4 Model DS-109 Double-Stub Tuner.

The DS-109 Double-Stub Tuner, furnished as an accessory with the HO-1 Heterodyne Mixer-Oscillator, is used with the HO-1 in second and third harmonic mode operation. Operation of the HO-1 system in the fundamental mode is satisfactory without the double-stub tuner, but performance will be enhanced with its use.

The DS-109 is a variable RF impedance transformer used to match a wide range of impedances. It is inserted in the RF signal path at the input to the second mixer of the HO-A, and is used to transform the input impedance of the mixer to the line impedance. In addition, the tuner transforms the proper RF interface impedance to the input of the second mixer for the reinforcement of the proper harmonic signal and the suppression of undesired overtones as required for efficient harmonic mixing action within the second mixer.

The DS-109 is provided with adjustable spacing between the stubs so that a spacing can be selected for each frequency to obtain rapid convergence to a match. An instruction plate is permanently mounted on the instrument indicating the preferred stub position for a particular frequency. Collet-type locks are provided to prevent accidental movement of the stubs after they have been set.

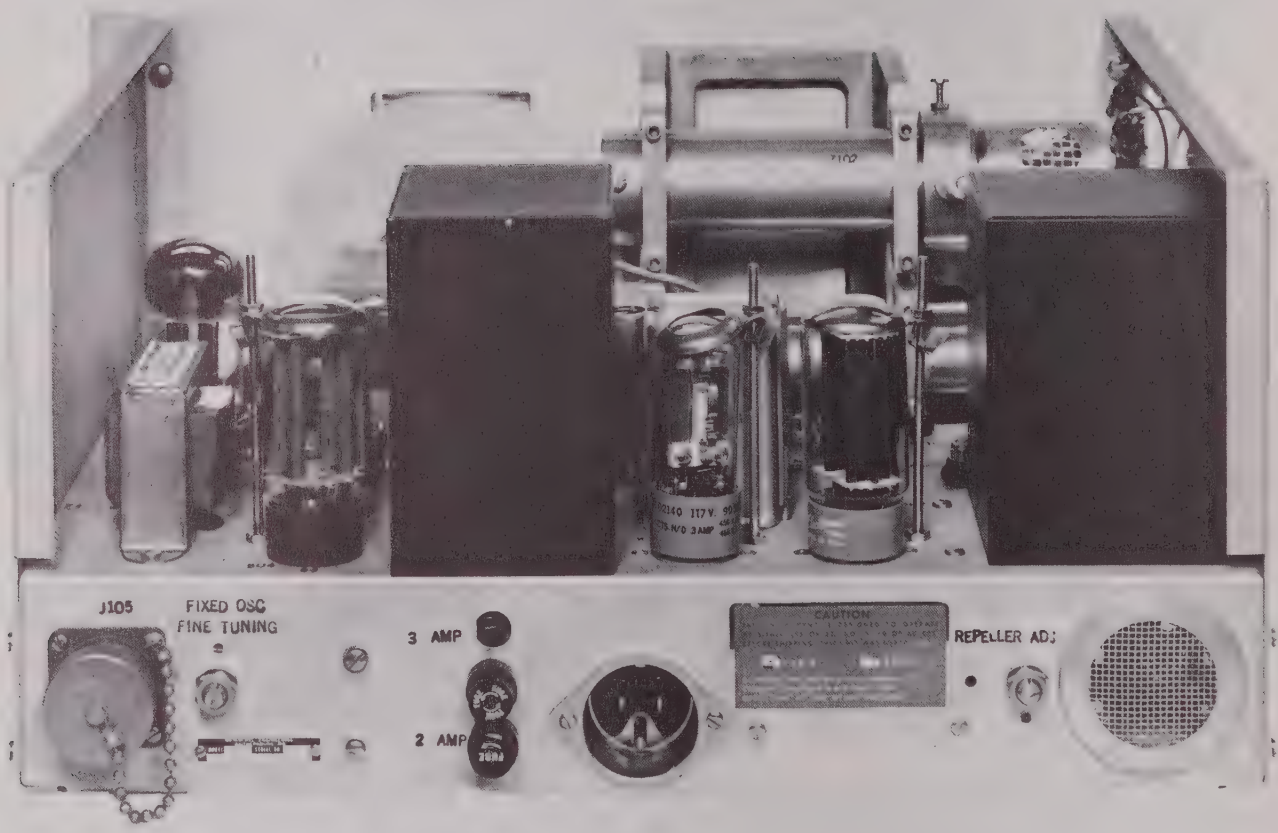

Figure 2.3. HO-1 Oscillator Module, Rear View

SECTION 3

INITIAL PREPARATION FOR USE

3.1 UNPACKING

The Model HO-1 Heterodyne Mixer Oscillator is shipped in two separate packing cases. This packing complies with MIL-P-116D, Method III, and will meet packing requirements for export shipments. Markings on the crate are in accordance with MIL-STD-129. Exercise normal care when removing the equipment, and make sure each piece of equipment is accounted for. A list of equipment supplied is found in paragraph 1.4.5, page 1-7.

Carefully remove the metal shipping clamp from the COARSE TUNING control knob on the front panel of the HO-1. Save the clamp for use in possible reshipment.

Examine the instrument for physical damage. Notify the shipping company immediately if evidence of damage is found. If shipped F.O.B. Gaithersburg, Maryland, damage claims must be collected by the consignee. Do not destroy the shipping cartons or packing material until after an agent of the shipping company has examined them. Do not return the instrument to Weinschel Engineering until a claim for damage has been established.

3.2 INSTALLATION

The HO-1 Oscillator module is self-contained within its own cabinet for use on a laboratory workbench. It may be removed from its cabinet and mounted in a standard 19" relay rack if desired.

The HO-A Mixer module is also self-contained within its own cabinet and is for use on a laboratory bench only. Should it become necessary to separate the HO-A and the 30-mc receiver to any extent, care should be taken to minimize the length of the IF cable between the HO-A and the receiver. Excess cable length will degrade the noise figure of the receiver.

Care must also be taken to make sure that no part of the HO-1/VM-3 system is located in a strong magnetic or electrical field.

3.3 PRELIMINARY OPERATIONAL CHECK

1. Connect the power cord between the receptacle on the rear of the HO-1 chassis and the 50/60 cps AC line. See the red CAUTION label on the rear apron of the chassis for the proper line voltage.

2. Interconnect the HO-1 and HO-A in the DUAL CONVERSION mode as shown in figure 3.1.

3. Set the LEVEL ADJ. control fully clockwise, turn the AFF switch OFF, and set the FINE TUNING control to mid-position.

4. Turn the POWER switch ON; the green POWER indicator light should come on. In 90 seconds the high voltage should come on as indicated by the red POWER light. If either light fails to come on, check the fuses and the lamps.

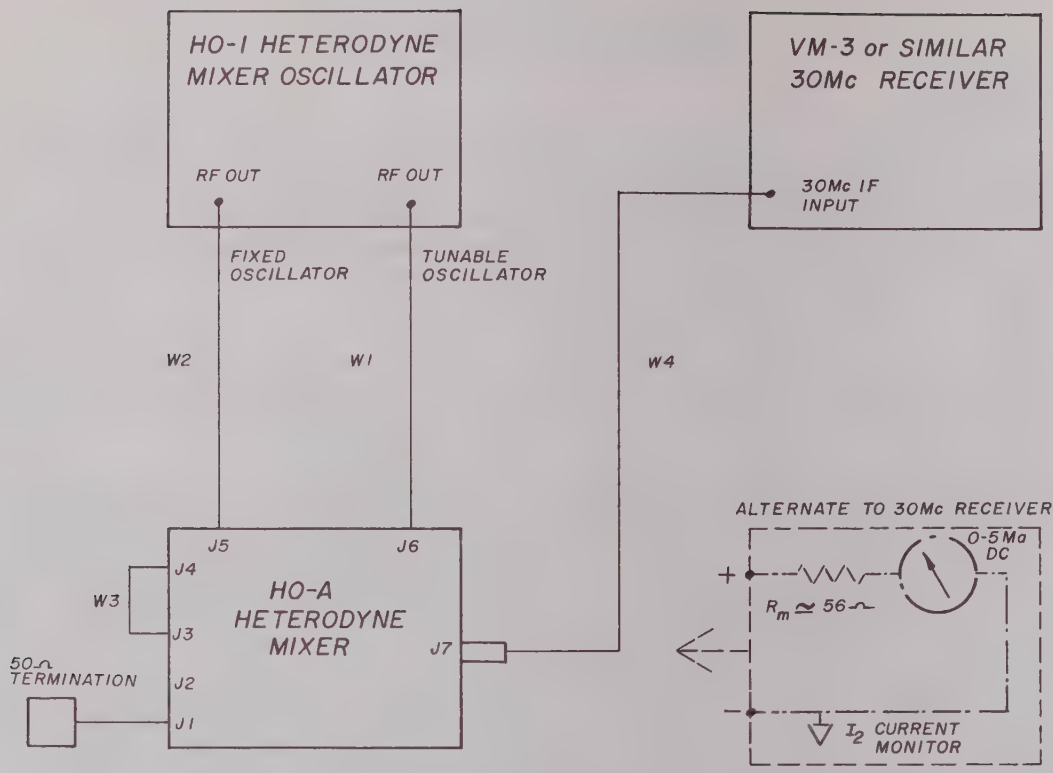

Figure 3.1. Preliminary Operational Check Setup

If the red light fails to come on, check to see that the 90-second thermal delay relay, K-102, is secure in its socket.

5. With the high voltage on, the second mixer diode current I_2 should be .75 to .85 ma.

NOTE

The second mixer diode current I_2 should be monitored on a meter internal to the receiver in use. The DC meter circuit is completed when the 30-mc IF cable W4 is connected between the HO-A IF output jack and the 30-mc input jack of the VM-3 receiver. If the receiver does not contain such circuitry, I_2 may be checked with an external laboratory-grade 0-5 milliameter with an internal resistance of approximately 56 ohms by connecting it between the center conductor of J7 and ground. This meter is removed when the HO-A is connected to the receiver. See figure 3.1.

6. If I_2 is much higher or lower than this .8 ma nominal figure, or if the current indication is erratic, a malfunction is indicated; refer to Section 5, the Maintenance Section of this Manual, for help in localizing the trouble.

7. Increase the LEVEL ADJ. control until the first mixer diode current I_1 is between 1.70 and 2.25 ma, and maintain this current with the LEVEL ADJ. control while slowly turning the COARSE TUNING control to scan the DUAL CONVERSION scale of the SIGNAL FREQUENCY dial from 10 mc to 2000 mc. Use the FINE TUNING control to peak the current indication if necessary. The observed minimum I_1 throughout the frequency range should be 1.70 ma.

8. If I_1 falls below 1.70 ma or behaves erratically, refer to the Maintenance Section for help in localizing the trouble.

The HO-1 Heterodyne Mixer Oscillator is now ready for use.

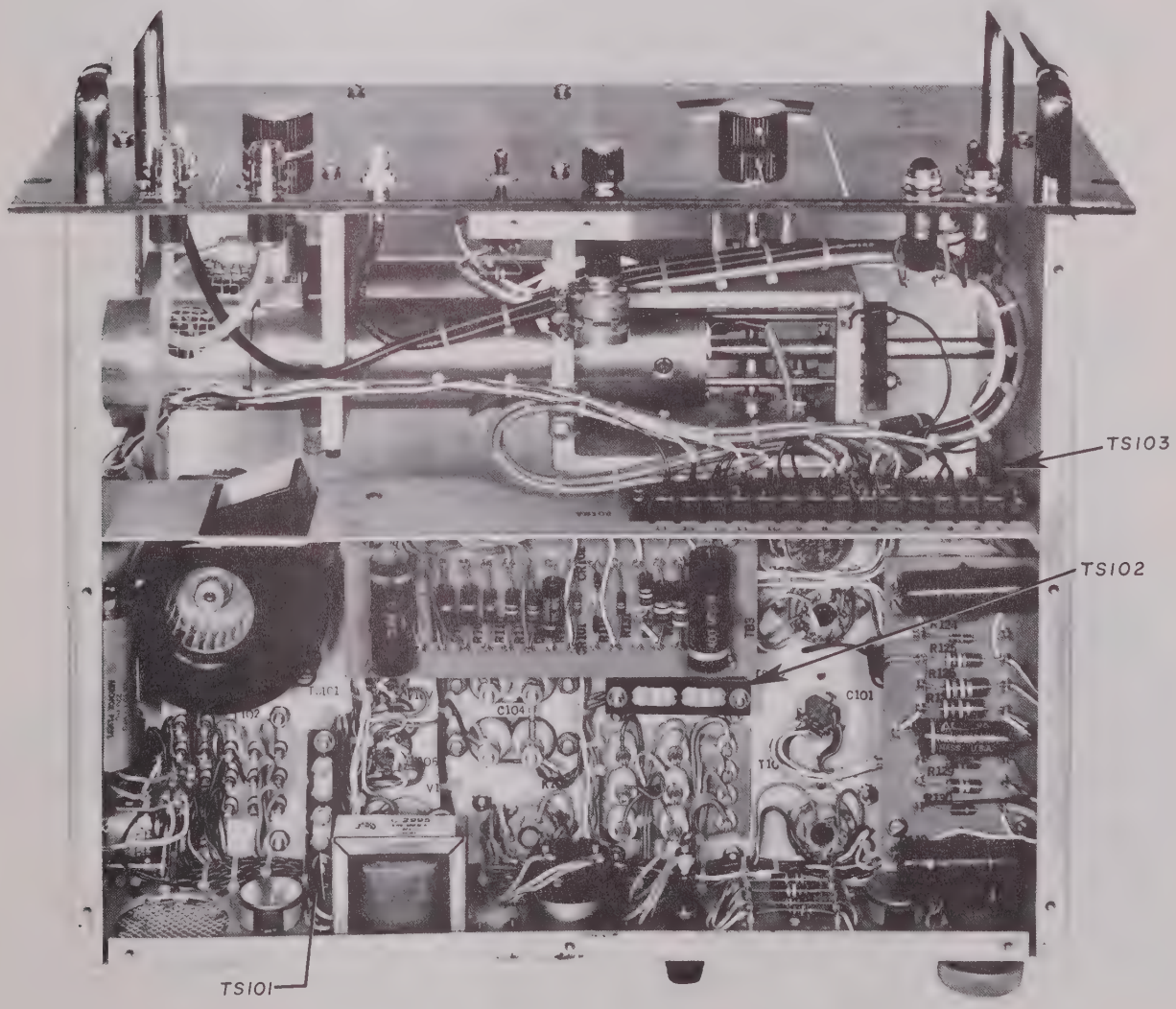

Figure 3.2. HO-1 Oscillator Module, Bottom View Showing Terminal Strips

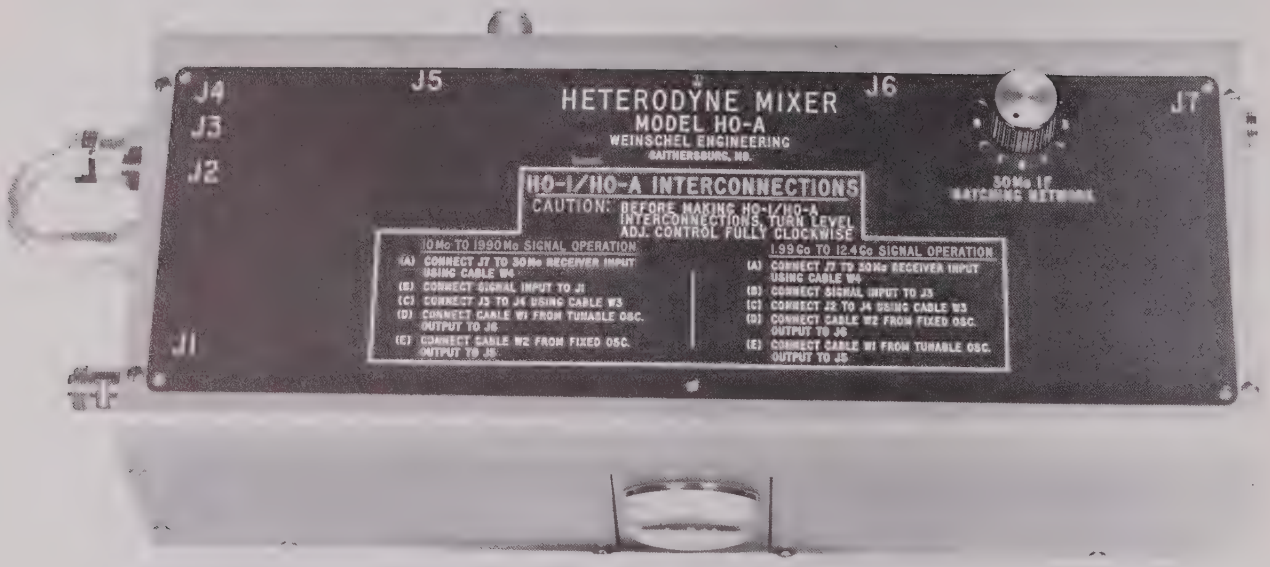
J4
J3
J2
J1
J5
J6
J7
HETERODYNE MIXER
MODEL HO-A
WEINSCHEL ENGINEERING
GAITHERSBURG, MD.
HO-1/HO-A INTERCONNECTIONS
CAUTION: BEFORE MAKING HO-1/HO-A INTERCONNECTIONS, TURN LEVEL ADJ. CONTROL FULLY CLOCKWISE
10Mc TO 1990Mc SIGNAL OPERATION
(A) CONNECT J7 TO 30Mc RECEIVER INPUT USING CABLE W4
(B) CONNECT SIGNAL INPUT TO J1
(C) CONNECT J3 TO J4 USING CABLE W3
(D) CONNECT CABLE W1 FROM TUNABLE OSC. OUTPUT TO J6
(E) CONNECT CABLE W2 FROM FIXED OSC. OUTPUT TO J5
1.99Gc TO 12.4Gc SIGNAL OPERATION
(A) CONNECT J7 TO 30Mc RECEIVER INPUT USING CABLE W4
(B) CONNECT SIGNAL INPUT TO J3
(C) CONNECT J2 TO J4 USING CABLE W3
(D) CONNECT CABLE W2 FROM FIXED OSC. OUTPUT TO J6
(E) CONNECT CABLE W1 FROM TUNABLE OSC. OUTPUT TO J5
30Mc I.F. MATCHING NETWORK

Figure 3.3. HO-A Mixer Module, Top View

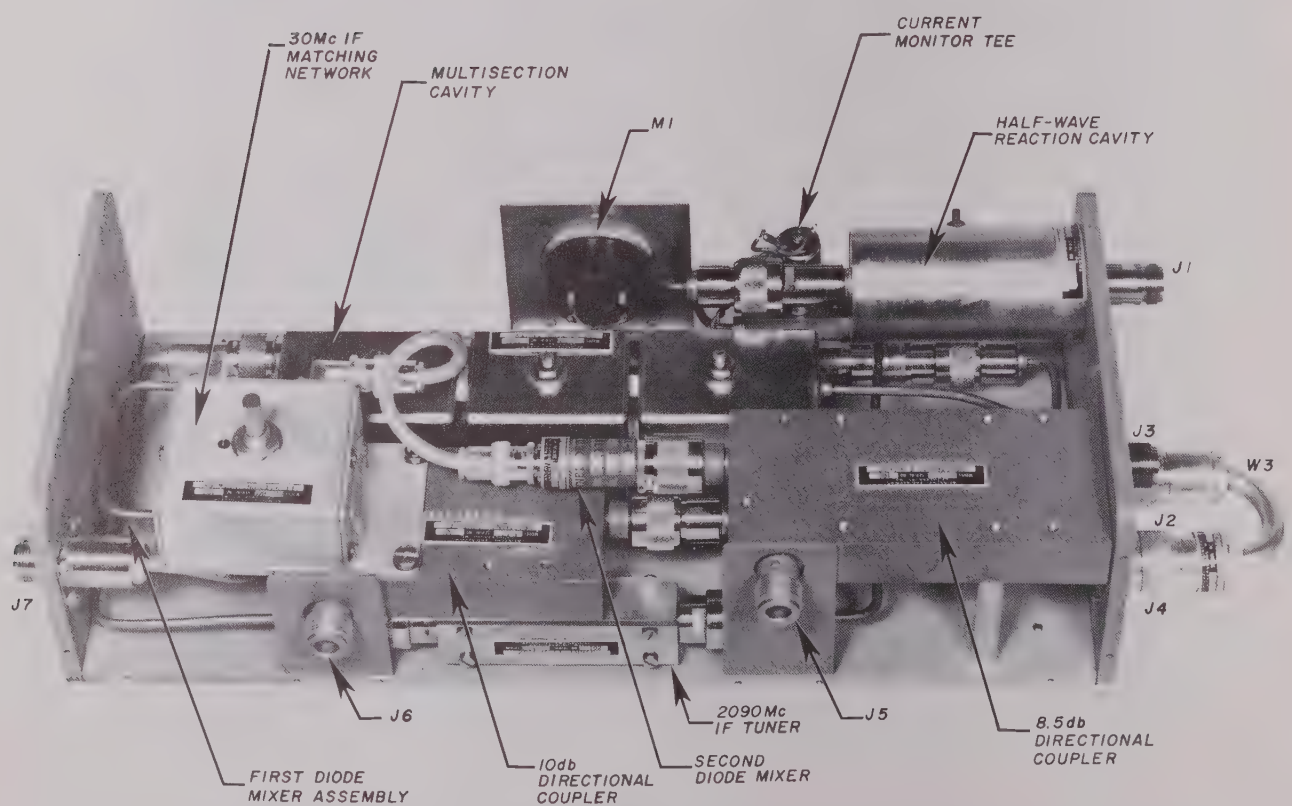

Figure 3.4. HO-A Mixer Module, Top Rear Interior View

SECTION 4

OPERATING INSTRUCTIONS

4.1 POWER

The Model HO-1 can be operated from either 115 or 230 volts AC, 50/60 cycles. Each unit is wired for 105-125V operation. See paragraph 5.3.6 for operation at 230V.

4.2 SETUP PRECAUTIONS AND CONSIDERATIONS

When high-resolution measurements are made in a microwave system, past experience with microwave hardware and one's individual measurement techniques become invaluable assets. This is especially true when the Model HO-1 Heterodyne Mixer Oscillator is used in conjunction with the Model VM-3 Attenuator and Signal Calibrator. The high accuracy and resolution of the optical readout system of the VM-3 bring out the shortcomings of many RF components which might have seemed adequate in lesser systems. For this reason, we would like to point out some of the problems which could arise in the external RF setup.

4.2.1 Leakage and Repeatability

When RF power ratio measurements are made over a large dynamic range (20 db or more), precautions must be taken against errors due to leakage. Figure 4-1 shows the error which can be caused by leakage. Due to the high detection sensitivity of the HO-1/VM-3 system, the signal level difference between the generator and the HO-A signal input might be as high as 95 db. Let us assume that the leakage signal into the HO-A signal input is 130 db below the generator output level. Let us further assume that a 10 db attenuator should be measured in a system where the HO-A input level is 90 db below the generator output level. With the attenuator under test removed from the system, the leakage signal is 40 db below the measurement signal. With the 10 db attenuator inserted, the leakage signal is only 30 db below the measurement signal, which might cause a maximum error of 0.2 db as seen from figure 4.1.

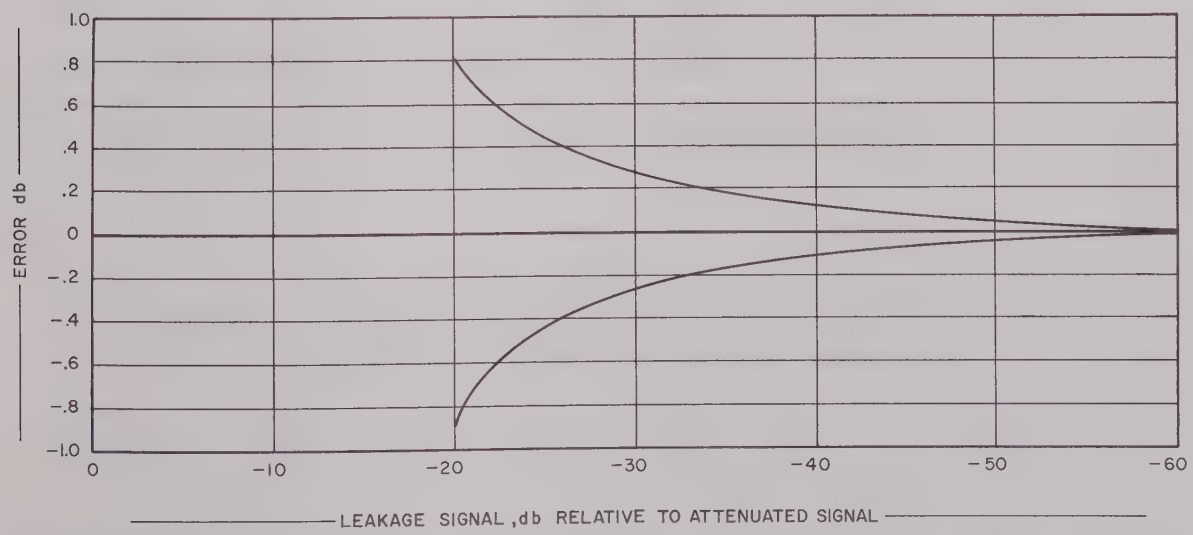

Figure 4.1. Maximum Possible Error Due to Leakage and Signal

Leakage can be caused by unshielded RF sources (badly shielded signal generators, leaky RF cavities, improperly bypassed supply leads to microwave oscillators, etc.), improperly shielded RF cables, badly mounted cable connectors, bent waveguide flanges, microwave components with large openings such as slide screw tuners, certain variable attenuators, slotted lines, wavemeters, etc.

During insertion loss measurements, the device under test must be physically removed and reinserted into the transmission system. To obtain good repeatability (0.01 db or better) compatible with the attainable repeatability of the Model VM-3, proper alignment is mandatory. Fixtures such as the Weinschel Model MB-1 Measurement Bench or precision optical benches for waveguide setups are very helpful.

To obtain stable operation in any RF measurement system, the following rules-of-thumb must be observed:

* Coaxial connectors must engage correctly.

* Type N connector gaskets must be removed for metal-to-metal contact.

* The slotted male outer conductor of Type N connectors must be straight.

* The slotted female fingers of Type N connectors must be bent inward properly.

* Components must be supported at small enough intervals to avoid excessive sag.

* The laboratory work bench must be sturdy enough to prevent the transmission of microphonics to the setup.

* Waveguide flanges must be free of nicks and burrs and connected with waveguide screws of the correct type.

In short, the entire setup must be as rigid and well supported as possible, and there must be no sag, stress, or unnecessary flexing of the system.

The use of high quality components and connectors cannot be over-emphasized, and will determine whether the entire dynamic range of the instrumentation can be realized.

4.3 EQUIPMENT REQUIRED

4.3.1 RF Sources. For small-signal measurements with the HO-1/VM-3, RF sources used should be capable of 100% square-wave modulation at 1000 cps. Weinschel Engineering manufactures RF sources covering the frequency range from 5 mc to 12.4 gc.

RF sources must provide at least -10 dbm output available at the HO-A input in order to use the full dynamic range of the HO-1 VM-3 receiver system.

The frequency stability of most RF sources is quite sufficient. However, an appreciable frequency shift can be tolerated only if broadband components

are used in the HO-A setup. Small frequency variations in generator output can cause appreciable error when, for example, the double-stub tuner is used with the HO-1 in the harmonic modes of operation, since the tuner presents impedances which vary greatly with frequency.

The RF generator should also possess a high degree of amplitude stability since any variation in the output during a measurement will result in error. The MS-1, MS-2, and MS-3 (50 mc to 2000 mc) generators manufactured by Weinschel Engineering are provided with a form of AGC for amplitude stabilization.

Table 4.1 lists recommended RF signal sources:

Table 4.1

RF Signal Sources

Frequency Range (gc)	Manufacturer	Model Number	Power Supply Required
0.005 - 0.05	Weinschel	MS-15	Weinschel Model MO-3* & MO-5*
0.05 - 0.25	Weinschel	MS-1	None
0.05 - 0.25	Weinschel	MS-12A	Weinschel Models MO-3* & MO-5*
0.25 - 0.92	Weinschel	MS-2	None
0.25 - 0.92	Weinschel	MS-13	Weinschel Models MO-3* & MO-5*
0.90 - 2.00	Weinschel	MS-3	None
0.90 - 2.20	Weinschel	MS-8	Weinschel Models MO-3* & MO-5*
2.10 - 4.20	Weinschel	MS-9	Weinschel Models MO-3* & MO-5*
4.00 - 7.30	Weinschel	MS-10	Weinschel Models MO-3* & MO-5*
7.20 - 10.50	Weinschel	MS-11	Weinschel Models MO-3* & MO-5*
7.00 - 10.00(H-Band)	Weinschel	MS-30	Weinschel Models MO-4, KC-1, MO-1C
8.20 - 12.40(X-Band)	Weinschel	MS-31	Weinschel Models MO-4, KC-1, MO-1C

* Includes modulator.

4.3.2 30-mc Receivers.

The Model HO-1 Heterodyne Mixer Oscillator was specifically designed for operation with the Model VM-3 Attenuator and Signal Calibrator. Although the HO-1 will work well with other 30-mc receivers, use of the VM-3 is strongly recommended for the following reasons.

* Complete AFF compatibility;

* HO-A 30-mc IF output matching compatibility to VM-3 input;

* VM-3 internal monitoring capability of HO-A second diode mixer current, I_2;

* Highest system sensitivity resulting from proper matching, integrated design, etc.

Because of the above factors, measurement results obtained from use of the HO-1/VM-3 system can be expected to be superior to those obtained from use of another receiver.

4.4 HO-1 EQUIPMENT SETUPS

The following paragraphs describe the equipment setups preparatory to making measurements in the four signal-frequency bands.

NOTE

Before interconnecting the HO-1 and HO-A, turn the LEVEL ADJ. control fully clockwise. This setting will limit the RF output power of the tunable oscillator and prevent possible damage to the mixer diodes. Similarly, during operation reduce the LEVEL ADJ. control a half-turn before changing the SIGNAL FREQUENCY dial setting.

NOTE

Be sure to connect the automatic frequency follower cable between the HO-1 and the VM-3. If another receiver is used which does not have compatible AFF capability, be sure to turn the AFF switch OFF.

NOTE

The HO-1 fixed and tunable oscillators should always be operated CW only when used with the Model VM-3; square-wave modulation will cause measurement errors.

NOTE

In the event cable assembly W4 is not compatible with the location of the receiver input connector, replace W4 with the shortest possible substitute. Any excess cable length will tend to degrade the noise figure of the receiver.

4.4.1 DUAL CONVERSION Operating Mode (Signal Frequency 10 mc to 1990 mc.) Interconnect the HO-1, HO-A, and VM-3 with the accessory cables supplied as shown in figure 3.1. Interconnect the HO-1 AFF input jack and the VM-3 AFF output jack. Both of these connectors are on the rear of the respective units. When using other receivers with compatible AFF, modify the AFF cable as required.

1. Using the COARSE TUNING control, set the DUAL CONVERSION scale of the HO-1 SIGNAL FREQUENCY dial to the input signal frequency.

2. Turn the FINE TUNING control to mid-position.

3. Turn the HO-1 AFF switch ON, unless the receiver used has no compatible AFF capability.

4. Turn the HO-1 and VM-3 power ON. After 90 seconds, the HO-1 high voltage will come on. Allow at least 5 minutes warm-up time.

5. Turn the AFF function switch on the VM-3 to the OFF position. While monitoring the first mixer diode current I_1, increase the LEVEL ADJ. control until a diode current of 1.8 ma is observed. Set the VM-3 METER FUNCTION switch to the CRYSTAL CURRENT position and monitor the second mixer current I_2 on the main meter. I_2 should be approximately 0.8 ma at this time.

6. To properly center the HO-1 tunable oscillator operating mode, monitor the first mixer diode current, and turn the FINE TUNING control until the meter indication is peaked; leave the control in this position. Readjust the LEVEL ADJ. control until a diode current of 1.75-1.85 ma is observed. Take care when making this adjustment; currents in excess of 3 ma may damage the mixer diode.

This completes the preparatory adjustments as required in the measurement procedures which follow.

4.4.2 FUNDAMENTAL Operating Mode (Signal Frequency 1990 to 4150 mc. Interconnect the HO-1, HO-A, and VM-3 with the accessory cables supplied as shown in Figure 3.1. Interconnect the HO-1 AFF input jack and the VM-3 AFF output jack. Both of these connectors are on the rear of the respective units. When using other receivers with compatible AFF, modify the AFF cable as required.

1. Using the COARSE TUNING control, set the FUNDAMENTAL scale of the HO-1 SIGNAL FREQUENCY dial to the input signal frequency

2. Turn the FINE TUNING control to mid-position.

3. Turn the HO-1 AFF switch ON, unless the receiver used has no compatible AFF capability.

4. Turn the HO-1 and VM-3 power ON. After 90 seconds, the HO-1 voltage will come on. Allow at least 5 minutes warm-up time.

5. Turn the AFF function switch on the VM-3 to the OFF position. While monitoring the second mixer diode current I_2, increase the LEVEL ADJ. control until a diode current of 0.8 ma is observed. The first mixer diode current I_1 should be less than 0.85 ma at this time, and will have no bearing on the operation of the HO-A in the fundamental or harmonic modes.

6. To properly center the HO-1 tunable oscillator operating mode, monitor the second mixer diode current, and turn the FINE TUNING control until the meter indication is peaked; leave the control in this position. Readjust the LEVEL ADJ. control until a diode current of 0.75-0.85 ma is observed. Take care when making this adjustment; currents in excess of 2.6 ma may damage the mixer diode.

This completes the preparatory adjustments as required in the measurement procedures which follow.

4.4.3 HARMONIC Operating Modes (Signal Frequency 4150 mc to 12.4 gc.) Interconnect the HO-1, HO-A, and VM-3 with the accessory cables supplied as shown in Figure 3.1. Interconnect the HO-1 AFF input jack and the VM-3 AFF output jack. Both of these connectors are on the rear of the respective units. When using other receivers with compatible AFF, modify the supplied AFF cable as required.

1. Using the COARSE TUNING control, set the SECOND HARMONIC scale of the HO-1 SIGNAL FREQUENCY dial to the input signal frequency.

2. Turn the FINE TUNING control to mid-position.

3. Turn the HO-1 AFF switch ON, unless the receiver used has no compatible AFF capability.

4. Turn the HO-1 and VM-3 power ON. After 90 seconds, the HO-1 high voltage will come on. Allow at least 5 minutes warm-up time.

5. Turn the AFF function switch on the VM-3 to the OFF position . While monitoring the second mixer diode current I_2, increase the LEVEL ADJ. control until a diode current of 2.1 ma is observed. The first mixer diode current I_1 should be less than 0.85 ma at this time, and will have no bearing on the operation of the HO-A in the harmonic modes.

6. To properly center the HO-1 tunable oscillator operating mode, monitor the second mixer diode current, and turn the FINE TUNING control until the meter indication is peaked; leave the control in this position. Readjust the LEVEL ADJ. control until a diode current of 2.0-2.2 ma is observed. Take care when making this adjustment; currents in excess of 2.6 ma may damage the mixer diode.

This completes the preparatory adjustments as required in the measurement procedures which follow.

4.5 PREPARATION FOR MEASUREMENTS.

4.5.1 Measurement Errors Resulting from Non-Linearity.

4.5.1.1 High and Low Signal Input Levels to the HO-1.

The HO-1 Heterodyne Mixer Oscillator linearly converts the RF input signal to 30 mc. Linear mixing results in a 30-mc IF output voltage at the second IF output of the HO-1 which is linearly related to the amplitude of the rf input signal to the HO-A.

It is important that the HO-1 first and second mixers be used only over that portion of their operating characteristic where the IF output amplitude is linearly related to the RF input amplitude. The maximum input signal that can be handled by the first and second mixers without deviation from linearity is determined by the fixed oscillator and tunable oscillator RF output levels fed to the HO-A, which in turn has been determined by the mixer diode characteristics, noise, and the conversion loss of the mixer system.

In practice, high-level inputs (0.1 mw or -10 dbm) cause non-linear mixing action in the mixers which results in measurement errors. To limit this high-level signal input measurement error to approximate 0.2 db/10 db (10 mc to 12.4 gc), the signal input level to the HO-A signal input connectors should be limited to a maximum of -15 dbm (0.032 mw).

Similarly in practice, the minimum input signal that can be handled by the first and second mixers will be limited by the conversion loss and noise of the system.

The presence of mixer noise in the low input signal level region, approximately -100 dbm, is the main cause of measurement error observed in this region. Typically, in practice, low input signal level measurement errors in the various operating models of the HO-1 system are as follows:

Table 4.2

Error Due to Mixer Noise

Operating Mode	Signal Input Power	Approximate db error/10 db due to Mixer Noise
Dual Conversion	-100 dbm	0.2 db
Fundamental	-110 dbm	0.2 db
2nd Harmonic	-100 dbm	0.15 db
3rd Harmonic	-100 dbm	0.3 db

4.5.1.2 Variation of First and Second Mixer Diode Currents. Great care should be taken when making measurements to assure that the proper diode mixer currents I_1 and I_2 are maintained throughout the measurement procedures. Slight variations in the operating mixer diode current levels during a measurement can materially affect the measurement linearity observed. Proper diode currents are shown in table 4.3.

Table 4.3

Proper Diode Currents

Operating Mode	First Mixer Diode Current I_1 (ma)	Second Mixer Diode Current I_2 (ma)	Tunable Oscillator RF Output Power Required (mw)(approx.)
Dual Conversion	1.75 - 1.85	0.75 - 0.85	5 - 17
Fundamental	less than 0.85 (not significant)*	0.75 - 0.85	1 - 3
Second and Third Harmonic	less than 0.85 (not significant)*	2.0 - 2.2	8 - 17

Note: Approximately 1.5 mw output power required from fixed oscillator in all modes.
*J1 not terminated

4.5.2 Preparatory Adjustments for Making Attenuation Measurements with a Modulated Signal Source and the VM-3 Receiver.

1. Select the operating mode of the HO-1 to be compatible with the signal source selected for the measurement to be made. Follow the appropriate HO-1 setup procedure as outlined in paragraph 4.4.

2. Set up the equipment as shown in figure 4.2 or 4.3; use the

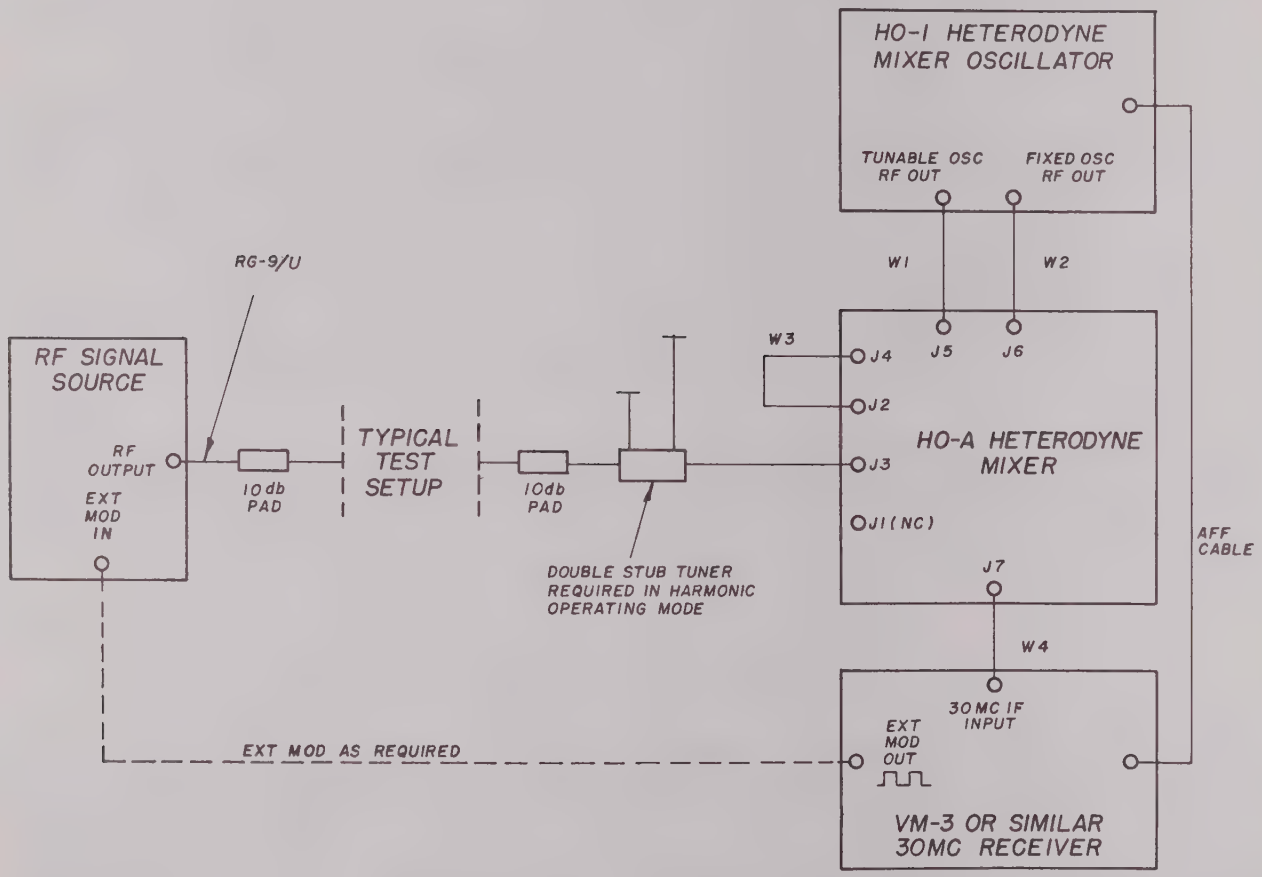

Figure 4.2. HO-1/VM-3 Receiver Test Setup, Fundamental and Harmonic Mode Operation

SQUARE WAVE output from the VM-3 for external modulation of the signal source, or the SINE WAVE output for external synchronization of the signal source internal square-wave modulation. The HO-1 is operated cw.

3. Adjust the signal frequency to the desired operating point with about -20 to -30 dbm input to the HO-A signal input connector J1 or J3. Turn the FUNCTION SELECTOR switch to RECEIVER EXT. MOD. Set the RECEIVER GAIN control to 75.

4. Vary the HO-1 COARSE TUNING control slightly until a change is observed on the FREQUENCY DEVIATION meter. This change may also be seen on a scope connected to the FM output. A scope indication may also be seen at the AM output in the form of a 1-kc square wave as shown in figure 4.4. Adjust the RECEIVER

GAIN control for a maximum output amplitude of 1 volt peak to peak at the AM output jack as a function of the COARSE TUNING control setting.

Continue to vary the tunable oscillator frequency with the COARSE TUNING control until the square wave disappears. The FREQUENCY DEVIATION meter should indicate approximately mid-scale. Vary the COARSE TUNING control in the opposite direction while observing the FREQUENCY DEVIATION meter. The meter should swing off-scale to one side, then back through zero to an off-scale indication on the

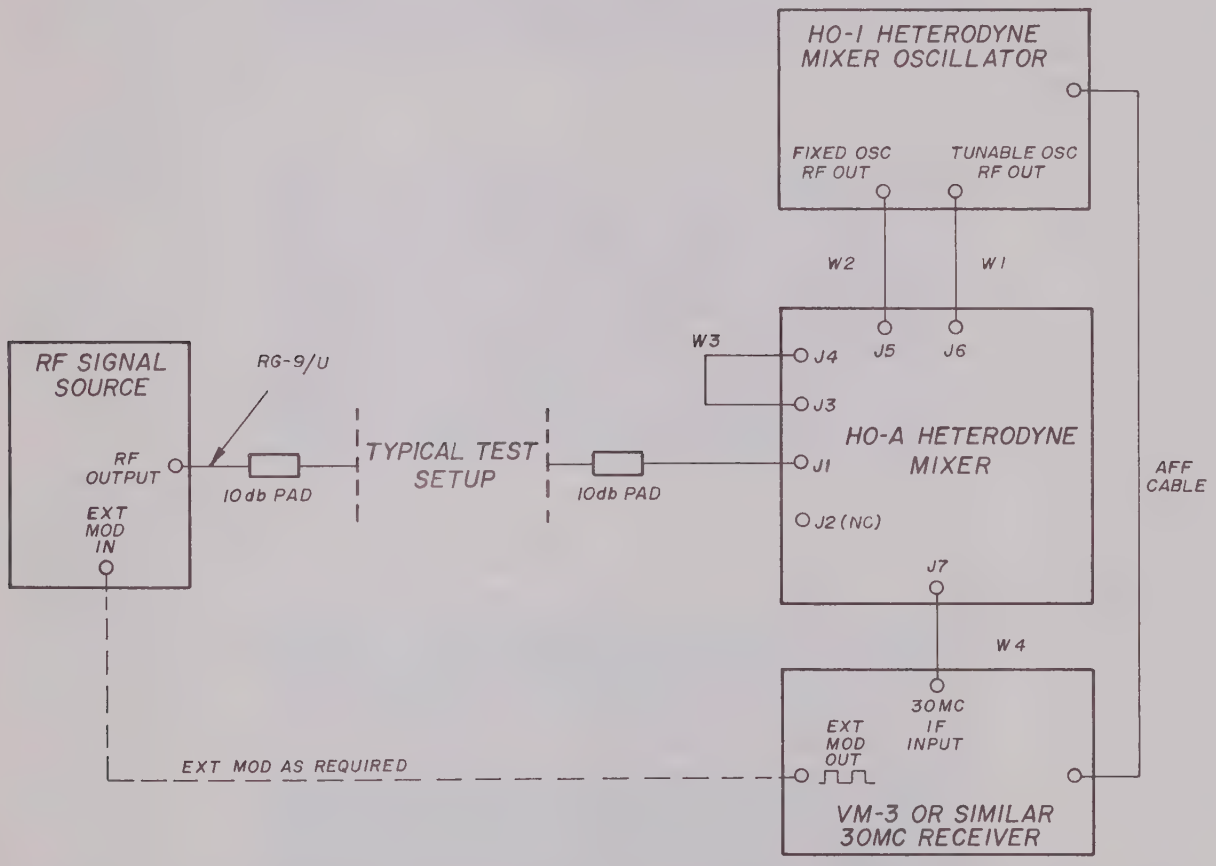

Figure 4.3. HO-1/VM-3 Receiver Test Setup, Dual Conversion Mode Operation

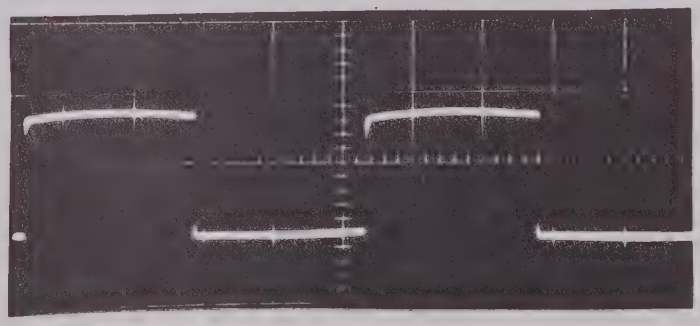

Figure 4.4. Square Wave Oscilloscope Pattern

opposite side, then back to remain near zero. This indicates that the beat frequency between the signal and the HO-1 oscillator has been swung completely through the IF bandpass. Again reverse the direction of the COARSE TUNING control, and after the meter has completed the first off-scale swing, stop the control as the meter indicates zero. Do not let it go off-scale in the opposite direction. Adjust the FINE TUNING control as required for a zero meter indication.

5. Turn the METER FUNCTION switch to the RECEIVER OUTPUT position and adjust the HO-A 30-mc IF matching network and the VM-3 TUNING control for maximum power transfer, reducing the RECEIVER GAIN as required to keep the main meter on scale. Occasionally check diode current I_1 and I_2 to maintain the required current. When operating the HO-1 in the second or third harmonic mode, the double-stub tuner connected to the HO-A input should be adjusted simultaneously for maximum power transfer and maximum diode current I_2 as indicated on the VM-3 main meter. Reduce the RECEIVER GAIN as required to keep the meter on scale and adjust the LEVEL ADJ. control to maintain the required diode current as outlined in table 4.3.

6. During the tuning described in step 5, the center frequency should be checked occasionally as in step 4. If the frequency is slightly off, readjust the FINE TUNING control as required. Due to the interaction between adjustment of the 30-mc IF matching network, diode current I_2 and the VM-3 TUNING control, the procedure of step 5 should be performed slowly and carefully to insure maximum sensitivity.

7. Turn the FUNCTION SELECTOR switch to ATTENUATION MEASUREMENT EXT. MOD. and observe the AM output wave form. Adjust the DUTY CYCLE until a symmetrical square wave is produced. Adjust the setting of the STANDARD ATTENUATOR until a straight line output is obtained. If a balance cannot be obtained, the modulation of the signal source and the VM-3 reference source are not operating in counterphase, and the scope patterns will appear as in figure 4.5 or 4.6. To correct

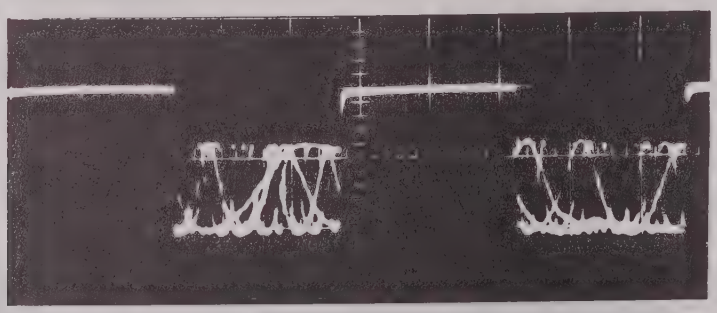

Figure 4.5. Modulations Not in Counterphase, External Modulation

this, place the 0° - 180° switch (located in the 1 KC SIGNAL FOR MODULATION section) in the opposite position. In the event that the sine wave output is being used to externally synchronize the internal modulation of the signal source, it will be necessary to adjust the FINE PHASE ADJUST and DUTY CYCLE controls to minimize the spikes present at the AM output. Refer to figures 4.7, 4.8, and 4.9 for scope patterns showing typical conditions.

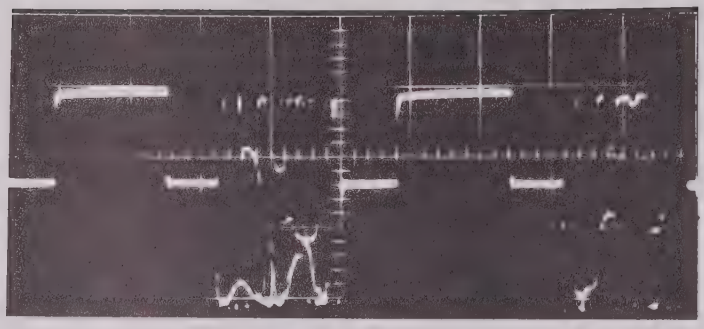

Figure 4.6. Modulations Not in Counterphase, External Synchronization

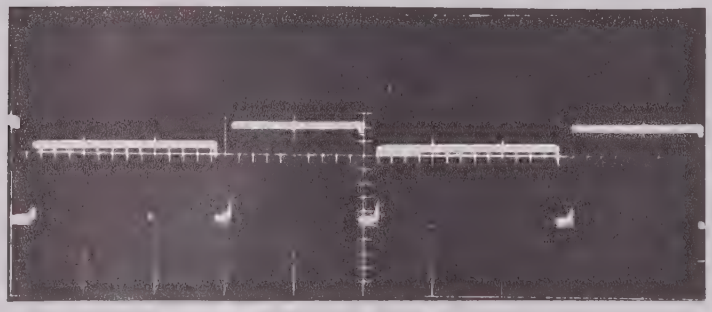

Figure 4.7. Modulations Phased but Improper Duty Cycle, External Synchronization

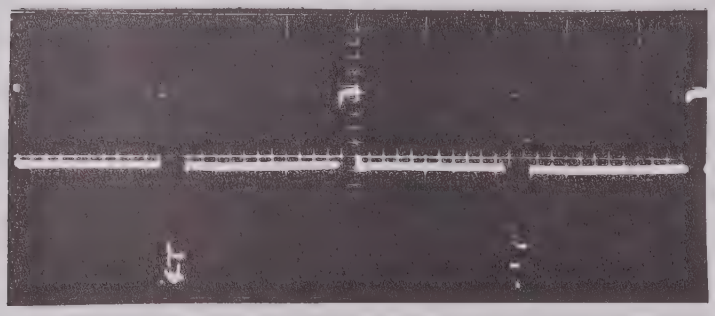

Figure 4.8. Duty Cycle Correct, but Fine Phase out of Adjustment

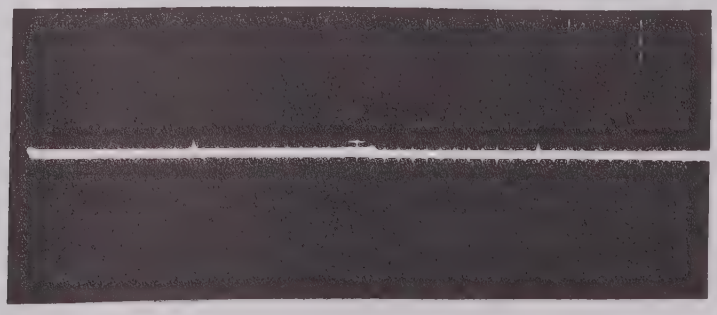

Figure 4.9. Duty Cycle and Phase Correctly Adjusted, External Synchronization

the RF source is operated CW. The HO-1 is also operated without modulation.

3. Set the AFF function switch to SLOW and the SLOW GAIN and FAST GAIN controls fully counterclockwise. Adjust the signal source to the desired operating frequency with about -20 to -30 dbm input to the HO-A signal input connector J1 or J3.

4. Set the ZERO SIGNAL BALANCE (red knob) control to mid-position. Set the FUNCTION SELECTOR switch to RECEIVER CW and the RECEIVER GAIN control to 75.

5. Vary the COARSE TUNING control slightly until a change is observed on the FREQUENCY DEVIATION meter. The change may be seen on the scope at the FM output connector. A scope indication may also be seen at the AM output in the form of a 1-kc square wave as shown in figure 4.4. Adjust the RECEIVER GAIN control for a maximum output amplitude of 1 volt peak to peak at the AM output jack as a function of the COARSE TUNING control setting.

Continue to vary the tunable oscillator frequency with the COARSE TUNING control until the square wave disappears. The FREQUENCY DEVIATION meter should indicate approximately mid-scale. Vary the COARSE TUNING control in the opposite direction while observing the FREQUENCY DEVIATION meter. The meter should swing off-scale to one side, then back through zero to an off-scale indication of the opposite side, then back to remain near zero. This indicates that the beat frequency between the signal and the HO-1 oscillator has been swung completely through the IF bandpass. Again reverse the direction of the COARSE TUNING control, and after the meter has completed the first off-scale swing, stop the control as the meter indicates zero; do not let it swing off-scale in the opposite direction. Adjust the FINE TUNING control as required for a zero indication.

6. Turn the METER FUNCTION switch to RECEIVER OUTPUT and adjust the DUTY CYCLE for a symmetrical square wave at the AM OUTPUT. Set the HO-A 30-mc IF matching network control to position 6 and adjust the VM-3 TUNING control for maximum power transfer as indicated on the main meter, reducing the RECEIVER GAIN as necessary to maintain an on-scale indication. Occasionally check the mixer diode currents to maintain the required current, and also check the frequency as in step 5. If the frequency is slightly off, readjust the FINE TUNING control as required. When operating the HO-1 in the second or third harmonic mode, the double-stub tuner connected to the HO-A input should be adjusted simultaneously for maximum power transfer and maximum diode current I_2 as indicated on the VM-3 main meter. Reduce the RECEIVER GAIN as required to keep the main meter on scale and adjust the LEVEL ADJ. control to maintain the required diode current as outlined in table 4.3.

7. Set the signal source off frequency and insert an additional 120 db or more of attenuation in the signal path to assure that the signal input power to the HO-A is less than -140 dbm. Turn the FUNCTION SELECTOR switch to ATTENUATION MEASUREMENT CW and set the STANDARD ATTENUATOR to 140 db. Press the DEPRESS FOR ZERO button and adjust the ZERO ADJUST control for a null on the AMPLITUDE BALANCE meter. Adjust the TUNING control for a zero indication on the FREQUENCY DEVIATION meter. Turn the 30-mc IF matching network control to lower the step number, and simultaneously adjust the ZERO SIGNAL BALANCE control until a reasonably stable null is obtained on the AMPLITUDE BALANCE meter. More than one null will be found; use that which requires the smallest clockwise rotation of the ZERO SIGNAL BALANCE control (lowest VM-3 internally generated noise level).

Interaction between the amplitude balance adjustment just completed and the frequency adjustment is normal. The TUNING control and the ZERO SIGNAL BALANCE control should be readjusted as required to properly null each meter indication. This procedure should be performed slowly and carefully to insure maximum sensitivity. If the balancing and tuning procedure is not properly performed, the FM output will appear as in figure 4.13. If the AMPLITUDE BALANCE and FREQUENCY DEVIATION nulls are not reasonably stable, leakage from another source operating at the same frequency should be investigated.

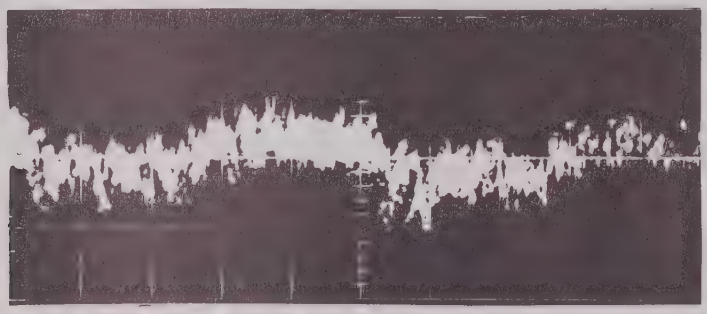

Figure 4.13. FM Output with Mismatch

8. Once stable indications have been obtained, set the METER FUNCTION switch in the RECEIVER OUTPUT position and the FUNCTION SELECTOR switch to the RECEIVER CW position. Reestablish the -20 to -30 dbm input to the HO-A and set the signal source frequency using the following procedure:

Vary the signal frequency slightly until a change is observed on the FREQUENCY DEVIATION meter. This may also be seen on the scope at the FM output. A scope indication may also be seen at the AM output in the form of a 1-kc square wave as shown in figure 4.4. Adjust the RECEIVER GAIN for an amplitude of about 1 volt peak to peak maximum at the AM output as the signal frequency is varied. Continue to vary the signal frequency until the 1-kc square wave disappears. The FREQUENCY DEVIATION meter should be approximately at mid-scale. Now vary the signal frequency in the opposite direction while observing the FREQUENCY DEVIATION meter. The meter should swing off-scale to one side, then back through zero to an off-scale indication on the opposite side; then back to remain near zero. This indicates that the beat frequency between the signal and the HO-1 tunable oscillator has been swung completely through the IF bandpass. Now again reverse the direction of change in the signal frequency, and after the meter has completed its first off-scale swing, stop varying the frequency as the meter passes through zero toward the opposite off-scale indication. The HO-1 tunable oscillator frequency should not be disturbed during this operation.

9. Set the FUNCTION SELECTOR switch to the ATTENUATION MEASUREMENT CW position. Adjust the signal level at the mixer input to -50 to -60 dbm and adjust the STANDARD ATTENUATOR for a straight-line indication at the AM output which should result in a null on the AMPLITUDE BALANCE meter.

10. With the FREQUENCY DEVIATION meter properly zeroed, switch the AFF OFF and adjust the AFF EQUALIZER at the rear of the top chassis for a null on the FREQUENCY DEVIATION meter. Switch back to AFF SLOW and slowly turn the SLOW GAIN clockwise. If the FREQUENCY DEVIATION meter immediately swings away from a null and a significant change in diode current is noted, the phasing must be reversed

by placing the AFF 0° - 180° switch (red knob) in the opposite position. Once this has been done, the AFF circuit will hold the signal and the HO-1 tunable oscillator frequency at a difference frequency that results in an HO-A IF output frequency equal to the VM-3 reference source frequency of 30 mc. If large variations in the mixer diode currents I_1 and I_2 (0.1 ma or more) continue to occur when the AFF gain controls are advanced, turn these controls fully counterclockwise and readjust the HO-1 FINE TUNING control until the diode current is peaked, and repeat steps 8, 9, and 10. If the SLOW GAIN is advanced too far, the resultant feedback may cause "motor-boating", which will be observed on the FREQUENCY DEVIATION meter and on the scope at the FM output jack. Keep the SLOW GAIN below this level. Next, switch the AFF SELECTOR to the SLOW AND FAST position, and slowly advance the FAST GAIN control to minimize the FM present. If the FM increases instead of decreasing, the scope pattern will resemble that shown in figure 4.14, in which case place the 0° - 180° switch (located in the 1 kc SIGNAL FOR EXT. MOD. section) in the opposite position.

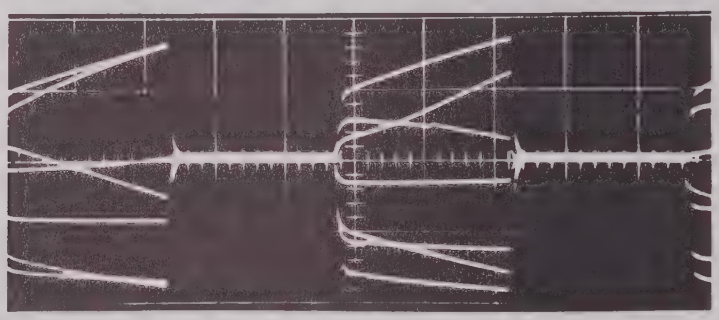

Figure 4.14. FM Output with Fast Signal out of Phase

Again, too much FAST GAIN will cause oscillation, so keep this gain below the oscillation point. Note that the AFF circuits will reduce but NOT eliminate the undesirable effects of source drift and FM.

11. The system is now set up to make attenuation measurements using a cw signal source. In general, the procedure is as follows: starting at some reference level, adjust the STANDARD ATTENUATOR and note the position on the optical readout. Next insert the attenuation to be measured (if the RF signal path is broken for this insertion, or the magnitude of the attenuation change is 50 db or more as in the case of signal generator output attenuator calibration, the AFF should be turned off before the large attenuation step is taken or the RF path is broken, and then returned ON after rebalancing) and null the AMPLITUDE BALANCE using the STANDARD ATTENUATOR. The difference between the reference position and the final position is the attenuation in db.

12. At the low input levels, the effects of RF leakage can create considerable error. To check for leakage, switch the AFF to OFF, set the STANDARD ATTENUATOR to 140 db, and break the signal line, or insert sufficient attenuation to insure that the signal level at the mixer input is -140 dbm or less. If leakage is present at the signal frequency, it will show up as a deflection of the AMPLITUDE BALANCE meter, which may be nulled with the STANDARD ATTENUATOR. The STANDARD ATTENUATOR reading at balance will be an indication of the magnitude of the leakage. Generally leakage is from the signal source and subsequent connections. To definitely determine that the leakage is from the signal source, switch the source off. If leakage indications persist, look elsewhere for another signal

source at the same frequency.

4.5.4 Preparatory Adjustments for Receiver Operation with the VM-3 and a Modulated Signal Source.

1. Follow the procedures outlined in paragraph 4.5.2 steps 1 thru 6.

2. The HO-1 and VM-3 are now set up to operate as a receiver of a 1-kc modulated signal. The minimum discernible signal should be less than -105 dbm, depending upon the HO-1 operating mode. For receiver operation at extremely low levels, AFF should not be used; instead, slightly vary the HO-1 FINE TUNING control or the signal frequency for maximum indication.

3. For detection of extremely low signal levels, it is desirable to externally modulate or synchronize the signal with the VM-3 1-kc signal and make use of the synchronous detector in the VM-3.

4. Turn the FUNCTION SELECTOR switch to the ATTENUATION MEASUREMENT EXT. MOD. position with the STANDARD ATTENUATOR set to 140 db. Press the DEPRESS FOR ZERO ADJUST button and zero the AMPLITUDE BALANCE meter using the ZERO ADJUST knob.

5. Extremely low signal levels may now be detected as a deflection of the AMPLITUDE BALANCE indicator. Note that under these conditions the RECEIVER GAIN control is inoperative, and sensitivity is controlled with the red SENSITIVITY control in the AMPLITUDE BALANCE section.

4.5.5 Preparatory Adjustments for Receiver Operation with the VM-3 and a CW Signal Source.

1. Follow the procedures outlined in paragraph 4.5.3 steps 1 thru 6.

2. Turn the signal source OFF and adjust the ZERO SIGNAL BALANCE control for minimum indication on the main meter. Turn the signal source ON.

3. The HO-1 and VM-3 are now set up to operate as a receiver of CW signals. The minimum discernible signal should be less than -105 dbm depending upon the HO-1 operating mode. For receiver operation at extremely low levels, AFF should not be used; instead, slightly vary the HO-1 FINE TUNING control or signal frequency for maximum indication.

4. For detection of extremely low signal levels, turn the FUNCTION SELECTOR switch to the ATTENUATION MEASUREMENT CW position and set the standard attenuator to 140 db. Turn the signal source OFF.

5. Press the DEPRESS FOR ZERO ADJUST button and zero the AMPLITUDE BALANCE meter with the ZERO ADJUST control. Adjust the ZERO SIGNAL BALANCE control for a null on the AMPLITUDE BALANCE meter. Turn the signal source ON.

6. Extremely low signal levels may now be detected as an indication on the AMPLITUDE BALANCE meter. Note that under these conditions the RECEIVER GAIN control is inoperative and sensitivity is controlled with the red SENSITIVITY control in the AMPLITUDE BALANCE section.

4.5.6 Setup Procedure Preparatory to Making Measurements with the HO-1 and Other 30-Mc Receivers.

1. Select the HO-1 signal frequency band for the test desired and a compatible CW or modulated signal source. Set up and interconnect the equipment as outlined in paragraph 4.4 and figure 4.2 or 4.3. When using a 30-mc receiver with compatible AFF, interconnect the HO-1 AFF input and the receiver AFF output using the AFF cable.

2. Using the COARSE TUNING control, set the HO-1 SIGNAL FREQUENCY dial to the input signal frequency.

3. Turn the FINE TUNING control to mid-position.

4. Turn the AFF switch ON, unless the receiver used has no compatible AFF capability.

5.. Turn the HO-1 and the receiver ON. After 90 seconds, the HO-1 high voltage will come on. Allow at least 5 minutes warm-up time.

6. To properly center the HO-1 tunable oscillator repeller operating mode, monitor the mixer diode current, and turn the FINE TUNING control until the meter indication is peaked; leave the control in this position.

7. Adjust the signal input to the desired operating point with -15 to -60 dbm input to the HO-A signal input jack J1 or J3.

8. If there is AFF capability in the receiver, turn it OFF, or reduce the AFF gain to zero. Slowly vary the HO-1 SIGNAL FREQUENCY dial until a signal is detected on the receiver output display.

9. Adjust the HO-A 30-mc IF matching network until the detected signal at the receiver output is maximized. Similarly, in the 2nd and 3rd harmonic modes of operation, the double-stub tuner connected to the HO-A signal input should be adjusted simultaneously for maximum power transfer and maximum mixer diode current I_2.

10. With the signal detected, monitor the mixer diode currents and adjust the HO-1 LEVEL ADJ. control as required to establish the proper current level. Readjust the FINE TUNING control to optimize the detected signal indication.

NOTE

Mixer diode current I_2 must be properly monitored during all measurements; the receiver in use must have provision therefore. If a diode current measurement circuit is not provided as part of the 30-mc input circuit of the receiver, the input must then provide a DC path to ground of 60 ohms or less. In addition, should it be necessary to monitor mixer diode current I_2 at the HO-A 30-mc IF output jack J7 with an external meter, always turn the HO-1 LEVEL ADJ. control fully clockwise before opening the 30-mc IF output circuit at J7. See NOTE, par. 3.3, p. 3-2.

11. Consult the operating instructions section of the instruction manual for the receiver in use. If compatible AFF capability is provided in the receiver, turn it ON and adjust the AFF gain as required to properly capture the signal. Should use of the AFF function radically alter the required HO-1 mixer diode current (a change of 0.1 ma or more), or cause oscillation, adjust the AFF phasing and gain at the receiver to reduce the mixer diode current variations and oscillations until the signal is properly captured.

The HO-1 and the receiver are now properly adjusted to make measurements according to procedures outlined in previous paragraphs.

4.5.7 The HO-1 Tunable Oscillator as a Signal Source.

The tunable oscillator section of the HO-1 oscillator module can readily be used as a stable 2020- to 4200-mc cw or modulated signal source with a controllable maximum RF output in excess of 5 mw over the frequency range. The actual frequency of the output signal is 30 mc higher than indicated on the FUNDAMENTAL scale of the SIGNAL FREQUENCY dial. The RF output power level available is adjustable with an internal variable attenuator controlled by the LEVEL ADJ. control on the HO-1 front panel.

1. Interconnect the HO-1 and associated test equipment as required. Use the COARSE TUNING control to set the FUNDAMENTAL scale of the SIGNAL FREQUENCY dial to an indication 30 mc lower than the desired signal source frequency. Turn the FINE TUNING control to mid-position. Turn the AFF switch OFF.

2. Turn the equipment power ON. After 90 seconds the HO-1 high voltage will come on. Allow at least 5 minutes warm-up time.

3. Turn the LEVEL ADJ. control fully clockwise to reduce RF output.

4. The HO-1 is now ready for use as a RF signal source. Adjust the LEVEL ADJ. and FINE TUNING controls as required.

Should the measurement procedures at hand require a modulated signal source, modulation of the HO-1 is described in the following paragraphs.

4.5.8 External Modulation of the HO-1 Fixed and Tunable Oscillators. When the HO-1 is used with the VM-3 and similar 30-mc receivers, the fixed and tunable oscillators should always be operated in the cw mode, since square-wave modulation of the HO-1 will result in measurement errors. However, an external MODULATION INPUT capability is provided for both the fixed and tunable oscillator in the HO-1 should the need arise.

If it should become necessary to make measurements requiring external modulation of either oscillator, as, for example, in the case where the HO-1 is used as a signal source, or where the particular receiver in use with the HO-1 will not properly function unless the HO-1 is modulated, either oscillator may be modulated by an external modulation function applied to either MODULATION INPUT connector.

Repeller modulation is used in both fixed and tunable oscillator operation, and since it is desirable in most cases to minimize incidental FM, it is suggested that square-wave modulation be used whenever amplitude modulation of the HO-1 is desired. If incidental FM is not a problem, during AM measurements involving

the HO-1, external sine-wave modulation will work as well as square-wave for 100% modulation of both fixed and tunable oscillators. If frequency modulation is required, both the fixed and tunable oscillators may be modulated with the appropriate external modulation function fed to the HO-1 modulation input connectors on the front panel. Modulation sensitivities of the fixed and tunable oscillators are approximately 100 kc/V and 250 kc/V, respectively.

External modulation of the HO-1 fixed and tunable oscillators can be accomplished as shown in figure 4.15, and as outlined in the following steps.

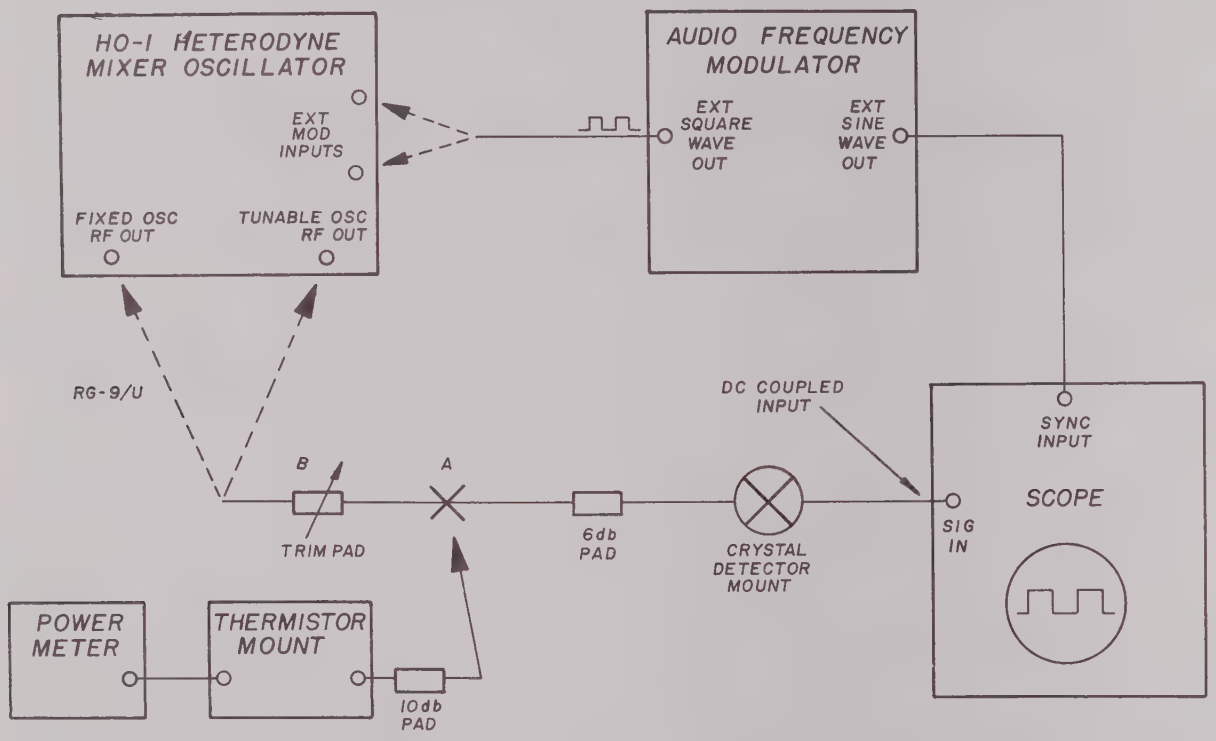

Figure 4.15. HO-1 External Modulation Test Setup

4.5.8.1 Modulation of the Fixed Oscillator.

1. Interconnect the HO-1 and associated equipment as shown in figure 4.15. Set the modulator for square-wave output. Turn the equipment power ON. After 90 seconds the HO-1 high voltage will come on. Allow at least 5 minutes for warm-up.

2. Reduce the modulation input to the HO-1 to zero. Open the RF signal path at point A and connect an RF power meter as shown.

3. Adjust the attenuator trim pad values at point B until an RF power level of approximately .2 to 1.0 mw is obtained. (In tunable oscillator modulation tests, the LEVEL ADJ. control is used to adjust the RF power level.)

4. Using a DC coupled scope preamplifier with the sensitivity control in the HIGH GAIN position, adjust the vertical position of the horizontal trace until it is aligned with the mid-scale line on the face of the scope. This

position is used as the zero input power reference point for subsequent measurements.

5. Disconnect the RF power meter and restore the RF signal path. This will result in a vertical deflection of the horizontal scope trace. Adjust the vertical sensitivity control for a vertical deflection of 2 cm or more. This second vertical position of the trace is the maximum power reference point.

6. As a result of interaction, a slight readjustment of the zero input power reference will be needed. Break the RF signal path at point A and repeat step 4 above.

7. Restore the RF signal path and repeat step 5. The zero and maximum reference points have now been established.

8. Increase the amplitude of the modulation signal until a square-wave pattern is visible on the scope. Adjust the horizontal sync and sweep controls until one or two cycles are visible.

9. Adjust the modulation signal amplitude to the HO-1 until the detected modulation envelope swings between the zero and maximum power reference points previously established. This constitutes 100% amplitude modulation of the oscillator RF output.

10. Disconnect the test setup from the oscillator output. The HO-1 is now ready for use in the measurement setup.

4.5.8.2 Modulation of the Tunable Oscillator.

1. Interconnect the HO-1 and associated equipment as shown in figure 4.15. Using the COARSE TUNING control set the SIGNAL FREQUENCY dial to the measurement frequency required. Turn the FINE TUNING control to mid-position.

2. If the AFF function is not used, or if there is no AFF capability in the receiver, turn the AFF switch OFF. Turn the AFF switch ON if the AFF cable is interconnected and the receiver has compatible AFF provisions. The receiver AFF, however, should be OFF.

3. Set the modulator for square-wave output. Turn the equipment power ON. After 90 seconds the HO-1 high voltage will come on. Allow at least 5 minutes for warm-up.

4. Perform steps 2 thru 9 as outlined in the previous paragraph, 4.5.8.1.

5. Reduce the modulation input to the HO-1 to zero.

6. To properly center the repeller operating mode to obtain 100% modulation with minimum incidental FM, turn the FINE TUNING control in either direction while monitoring the RF power level on the scope. Set the FINE TUNING control in a threshold position where the RF power drops to the zero reference point; leave the control in this position.

7. Increase the modulation signal amplitude to the HO-1 until a clean 100% AM waveform is obtained. Excessive modulation will cause spikes to appear on the pattern, indicating over-modulation.

NOTE

The modulation signal amplitude required for a given percentage of AM will vary with frequency as a result of variations in the klystron operating mode.

8. Disconnect the modulation test setup from the oscillator output. The HO-1 is now ready for use in the measurement setup.

NOTE

Operationally, when the HO-1 and HO-A are interconnected and external modulation of either oscillator is required, a convenient indication of proper modulation signal level can be had by monitoring the first or second diode currents, I_1 or I_2 respectively. Mixer diode current will drop to approximately half the normal cw level when 100% symmetrical square-wave AM is present.

4.5.9 Applications. There are many individual measurement applications for using the HO-1 in conjunction with the VM-3 and similar 30-mc receivers; these relate to the basic functions of the units involved, but for the most part differ only slightly in the external measurement setup.

The HO-1/receiver system can be used in typical setups:

1. To measure accurately the insertion loss of external devices,

2. To calibrate the output attenuator of a signal source,

3. To check the purity (incidental AM and FM) of cw signals,

4. As a sensitive receiver for measuring antenna patterns,

5. To measure RF leakage, and

6. As a 2020 to 4200-mc signal source with controllable maximum RF output in excess of 5 mw over the frequency range.

Figures 4.16 thru 4.19 show some of the more common equipment setups for these typical applications. For more detailed discussions of the various subjects, refer to the following bibliography:

"An Accurate Attenuation Measuring System with Great Dynamic Range"
B. O. Weinschel, Engineering Note No. 12, The Microwave Journal, Sept.1961.

"Calibration of Signal Generator Output Voltage in the Range 100 to 1000 Mc."
A. L. Hedrich, B. O. Weinschel, G. U. Sorger, and S.J. Raff.
IRE Transactions on Instrumentation, Vol. I-7, Nos. 3 & 4. Dec.1958.

"Survey of Precision Microwave Attenuation Measuring Techniques"
John E. Ebert and Gunther U. Sorger. Instrument Society of America Transactions, Vol. 3 No. 3 July 1964.

"Relative Voltmeter for VHF/UHF Signal Generator Attenuator Calibration."
B. O. Weinschel, G. U. Sorger, and A. L. Hedrich. IRE Transactions on Instrumentation, Vol. I-8, No. 1, March 1959.

U. S. Patent No. 3,104,354, Sept. 17, 1963 - B. O. Weinschel et al.
High Frequency Insertion Loss Test System Including Coupled Attenuators.

U. S. Patent No. 3,098,968, July 23, 1963 - B. O. Weinschel et al.
Standard Source Comparison System for High Frequency Voltage Ratio Meter Including Alternately Connectable Load Terminations.

U. S. Patent No. RE. 25396, June 18, 1963 - B. O. Weinschel.
Voltage Ratio Meter for High Frequency Calibration Systems.

Engineering Note No. 16, Weinschel Engineering Co., March 20, 1964
"Calibration of Signal Generators" - B. O. Weinschel.

(Copies of the above publications may be obtained without charge from Weinschel Engineering Co., Gaithersburg, Md. 20760.)

"Microwave Antenna Measurements" C. C. Cutler, A.P. King, and W.E.Kock.
Proceedings of the IRE, Vol. 35, p. 1462, December 1947.

"Measuring Microwave Antenna Patterns" - B. I. Small and C. M. Hatcher.
Electronics, Vol. 27, No. 11, p. 184, November 1954.

"Frequency Analysis Modulation and Noise" - H. Goldman. McGraw-Hill Company, Inc., New York, 1948. p. 248

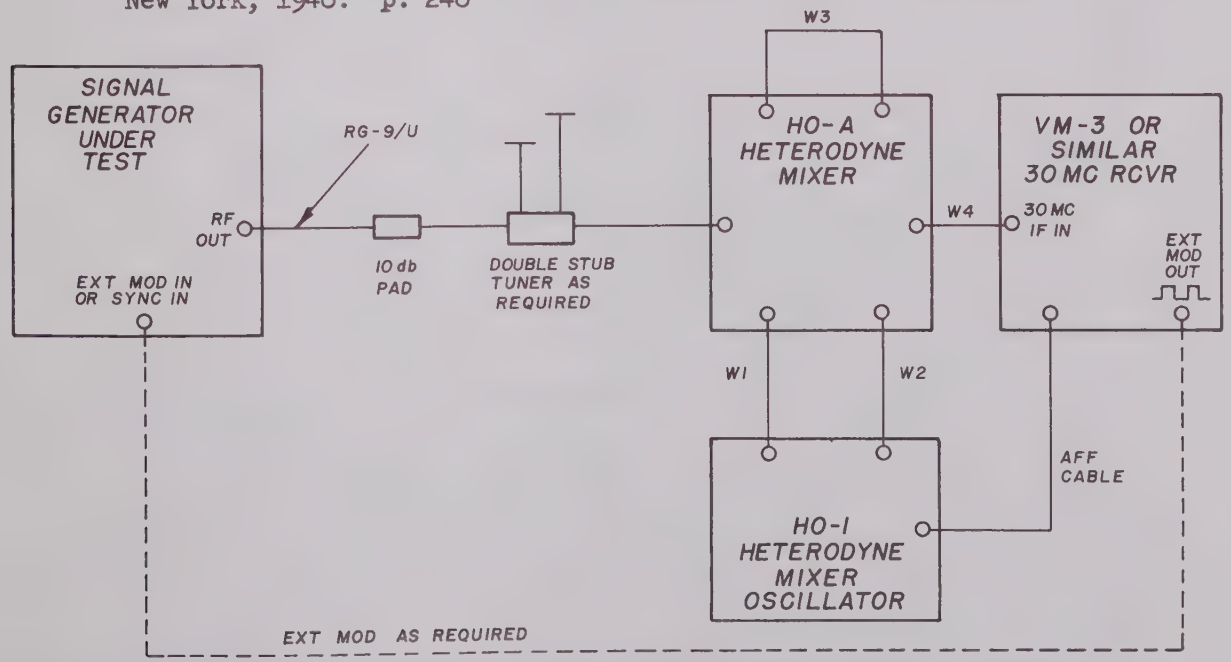

Figure 4.16. Typical Setup for Signal Generator Calibration

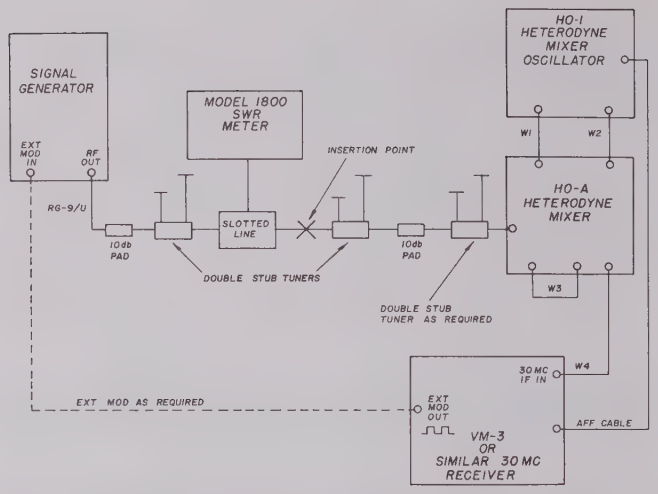

Figure 4.17. Typical Test Setup for Coaxial Insertion-Loss Measurements

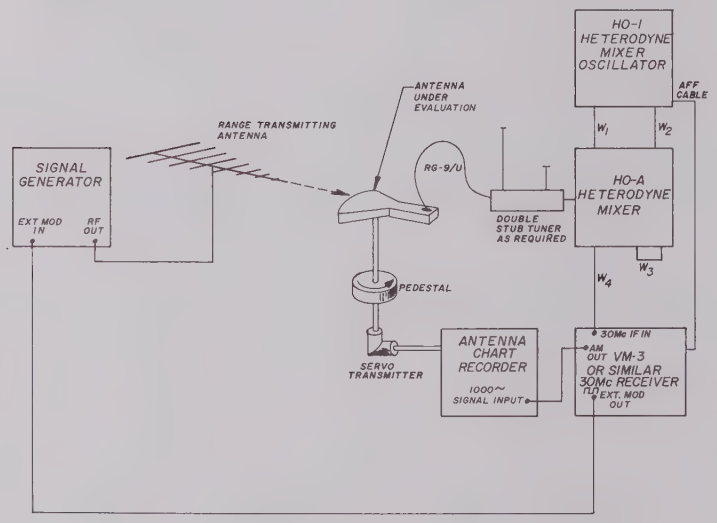

Figure 4.18. Typical Setup for Antenna Pattern Measurement

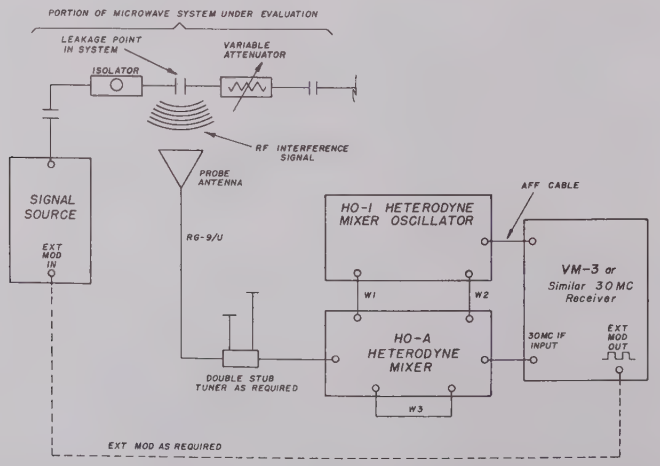

Figure 4.19. Typical Setup for Locating Source of RF Interference

SECTION 5

MAINTENANCE

5.1 GENERAL

The Model HO-1 Heterodyne Mixer Oscillator is designed for maximum operating life and will require a minimum of maintenance. Each unit is manufactured of the highest quality components, all of which operate well within their ratings. No special service tools or fixtures are required for maintenance or adjustment. All internal adjustments have been preset at the factory, and should not be moved except as specifically directed herein.

The HO-1/VM-3 is a precision test and measurement system; no attempt should be made to modify or "improve" either instrument for the purpose of exceeding the specifications. Such attempts without fail result in the return of the instrument to the factory for overhaul. Maintenance and repairs should be made only by skilled personnel with the recommended test equipment. Maintenance should not be hurried; sufficient time must be allowed for a thorough and precise job of repair and adjustment for optimum results.

Conscientious care in handling and operating this equipment will prolong its life and prevent trouble. It should be stored and operated in a clean, dry environment, free of dust, fumes, temperature extremes, vibration, and magnetic and electrical fields.

No regular inspections are required to keep the HO-1 in operating condition other than a constant vigilance for the little troubles resulting from everyday use: loose screws, loose knobs, dirt, dust, frayed cables, and the like. The instrument should be inspected after use in a severe environment, and accumulated dust, moisture, etc., removed with an air hose. When using air under pressure, take care not to cause any damage or maladjustments. Avoid overtightening nuts and screws.

5.2 MECHANICAL

DANGER

Use extreme care when making tests on this equipment with covers removed. Voltages up to 900 volts are present throughout the equipment; contact with these voltages could be injurious or fatal.

5.2.1 Cabinet Removal. To remove the HO-1 Oscillator module from its cabinet proceed as follows:

1. Disconnect all cables and assemblies.

2. Remove the four screws and the trim strips at the ends of the front panel.

3. Tilt instrument forward and set it up on the front panel handles. Gently lift the cover off.

4. To remove the bottom cover, turn the HO-1 around and remove the screws.

To remove the cover from the HO-A mixer module, proceed as follows:

1. Loosen the setscrews in the 30-mc IF matching network control knob and remove the knob.

2. Loosen and remove the lock-nut on the 30-mc IF matching network control shaft.

3. Loosen and remove the 22 screws securing the cover.

4. Gently lift the cover straight up until clear.

5.2.2 Lubrication.

1. Should the tunable oscillator rack-and-gear drive mechanism become dirty and stiff in operation, remove the HO-1 from its cabinet and clean the racks and gears and the pilot shaft with a soft cloth and a suitable solvent.

CAUTION

When using dry-cleaning solvents, work with adequate ventilation and avoid excessive inhalation of fumes. Certain petroleum solvents are flammable; do not use near fire or flame.

Lightly oil the racks and gears with a drop or two of SAE #10 oil, and lubricate the pilot shaft with a thin film of Molykote G. See figure 5.1. Avoid the accumulation of excessive lubricant.

2. The blower motor assembly should be lubricated approximately every three months. Two lubricating holes are located in the sides of the motor housing. Use a syringe type of applicator with Gulf LO-17, Harmony #53, or Stanoil #35. Do not overlubricate.

3. Lubricate the drive shaft and lead screw of the LEVEL ADJ. control approximately every nine months. Use ONE DROP of SAE #10 oil on each.

CAUTION

Avoid lubricating the tunable oscillator coupling loop plunger. See figure 5.2.

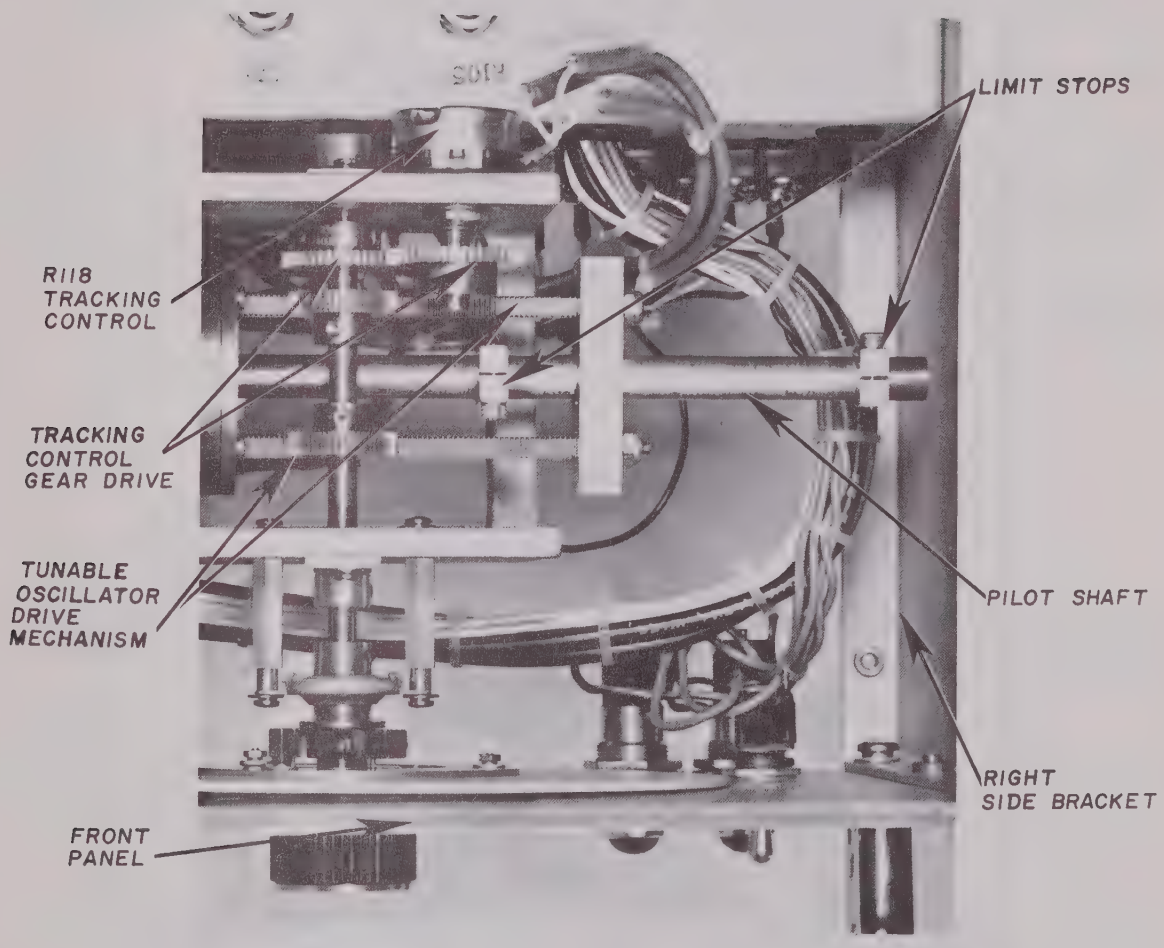

Figure 5.1. Top Right Interior View Showing Tunable Oscillator Drive

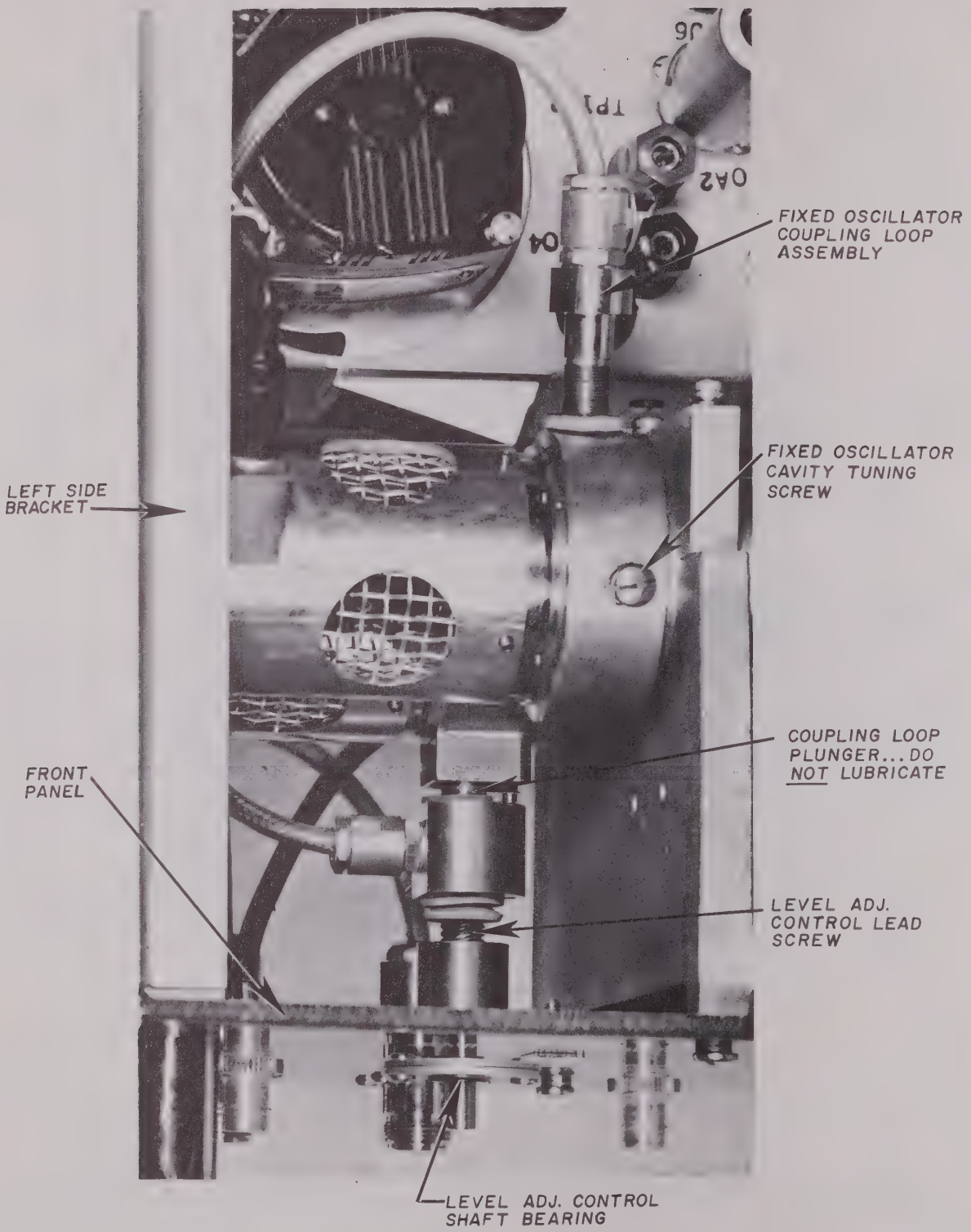
FIXED OSCILLATOR COUPLING LOOP ASSEMBLY
FIXED OSCILLATOR CAVITY TUNING SCREW
LEFT SIDE BRACKET
COUPLING LOOP PLUNGER... DO NOT LUBRICATE
FRONT PANEL
LEVEL ADJ. CONTROL LEAD SCREW
LEVEL ADJ. CONTROL SHAFT BEARING

Figure 5.2. Top Left Interior View Showing LEVEL ADJ. Drive

5.2.3 Klystron Tube Replacement

The 6BL6 RF oscillators V-109 and V-111 are each completely enclosed in their respective cavities and covers. To replace either, refer to figure 5.3 and follow the steps outlined below:

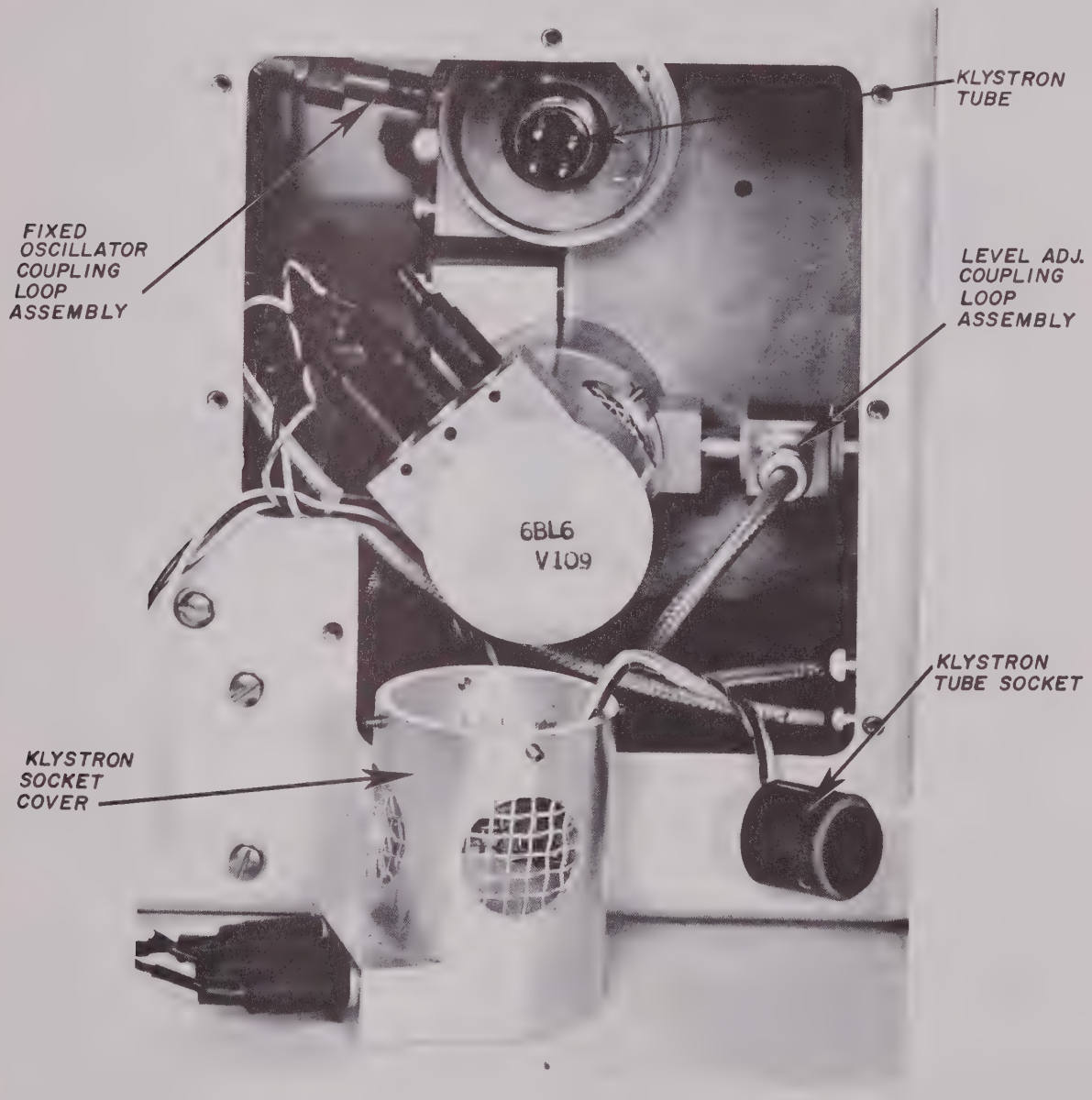

Figure 5.3. Left Side Interior View with Access Plate Removed

1. Remove the HO-1 oscillator module from its cabinet.

2. Remove the eight screws securing the access plate on the left side of the chassis. Remove the access plate and the air deflection plate.

3. Loosen the four Allen-head screws which lock the klystron socket cover to the large locking collar on the end of the oscillator assembly. Remove the cover.

4. Unscrew and remove the klystron locking collar. See figure 5.4.

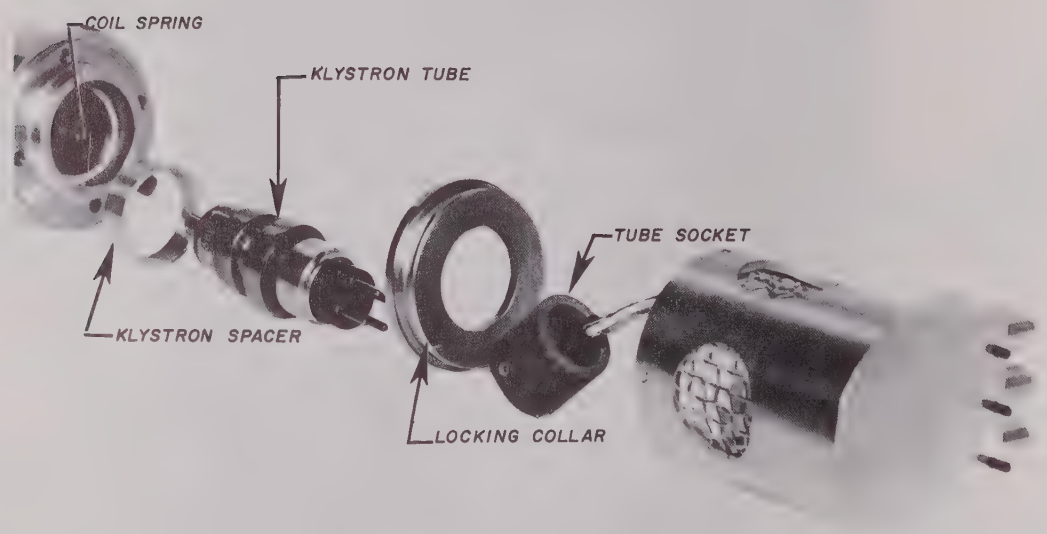

Figure 5.4. Klystron Tube Assembly, Exploded View

5. Remove the tube socket from the klystron and gently remove the klystron from its cavity.

6. Remove the klystron spacer and coil spring.

7. Examine the coil spring carefully; if damaged, replace with Weinschel part number A 121-246.

8. Insert the replacement klystron in the correct position. To determine the correct position of the tunable oscillator klystron, proceed as follows:

a. Turn the LEVEL ADJ. control fully clockwise.

b. Loosen the set screws and remove the LEVEL ADJ. knob.

c. Remove the two screws securing the LEVEL ADJ. drive mechanism to the front panel.

d. Grasp the drive mechanism with one hand in front of the panel and the other behind the panel, and carefully withdraw the RF probe.

e. Use a flashlight and look through the hole vacated by the drive mechanism to determine the correct position of the klystron. Adjust the penetration of the klystron within the assembly until the upper grid ring protrudes from the oscillator center conductor by approximately .020". This is the proper spacing for both the tunable and fixed oscillator cavities. Due to internal capacity variations in individual tubes, slight shifts in frequency may occur. To correct for this, the .020" spacing may be slightly varied as required. Reduced spacing increases the frequency.

To determine the correct position of the fixed oscillator klystron, proceed as follows:

a. Remove the four screws securing the fixed oscillator RF OUTPUT connector J102 to the front panel. Free the connector by pushing it through the panel.

b. Loosen the knurled locknut securing the RF coupling loop assembly.

c. Withdraw the assembly by rotating counterclockwise.

d. Use a flashlight and look through the hole vacated by the coupling loop to determine the correct position of the klystron. Adjust the correct position of the klystron as in step e above.

9. Replace the coil spring, making sure it seats properly. Reinsert the spacer until it is seated against the coil spring.

10. With the klystron seated properly, carefully replace the klystron locking collar and screw down tight with moderate hand pressure. Carefully check the klystron for security. If it is still loose, tighten the collar until the tube is held firmly.

11. Replace the tube socket.

12. Recheck to ascertain if the klystron has moved.

13. Replace the RF probe and associated hardware.

14. Orient and replace the klystron cover so as to clear obstructions. Secure the four Allen-head screws.

15. Replace the air deflection plate and the access plate with the screws provided.

16. Measure and adjust the oscillator frequency, klystron current, repeller voltage, RF coupling, and output power as outlined in this section.

5.2.4 Mixer Diode Assembly Replacement. The first and second diode mixers used with the Model HO-1 are contained in high-performance mixer assemblies designed exclusively for use in the HO-A mixer module. Caution: Under no circumstances should either mixer diode assembly be tested with an ohmmeter! If the diode is thought to be faulty, replace with a new mixer diode assembly. Each can be replaced only with an identical assembly purchased from Weinschel Engineering. See Section 6, Parts Lists, for the Weinschel part number and ordering information.

To replace either diode mixer assembly, proceed as follows:

1. Turn off all power and disconnect all cables.

2. Remove the cover from the HO-A.

3. Loosen the two screws holding the 30-mc IF matching network to the directional coupler.

4. Remove the IF matching network by disconnecting the BNC cable assemblies. There is now free access to the second mixer diode assembly.

5. Remove the three screws securing the right-hand chassis wall and remove the wall. There is now free access to the first mixer diode assembly.

The first mixer diode assembly is replaced as follows:

a. Refer to figure 5.5. Use an open-end wrench and carefully loosen the ram nut securing the first mixer assembly to the multisection cavity. Simultaneously remove by hand the ram nut and the type N connector.

b. Carefully manipulate and pull on the cable to withdraw the assembly from the cavity. The withdrawal must be done gently and with care so as not to misalign or damage the diode loop assembly.

CAUTION

Static electricity in the body of the person handling the assembly can cause permanent damage if discharged through the diode. Use extreme care in handling.

c. To connect the replacement assembly, refer to figure 5.6. Insert the diode loop assembly into the input of the multisection cavity and mate the type N connector to the 10-db coupler. A guide pin is provided within the multisection cavity for proper alignment of the loop as the assembly is inserted.

d. Push in on the cable to seat the assembly, and start the ram nut and N connector. Simultaneously tighten both by hand.

e. Finally tighten the ram nut with the open-end wrench using moderate pressure. Do not overtighten.

The second mixer diode assembly is replaced as follows:

a. Remove the BNC cable assembly from the 30-mc output connector on the mount.

b. Unloosen the knurled type N connector coupling nut from the directional coupler and remove the second mixer diode assembly.

c. To replace the assembly, reverse the above procedure.

d. Whenever the second mixer diode assembly is replaced, the 2090-mc IF tuner must be adjusted to optimize the RF power transfer to the new assembly.

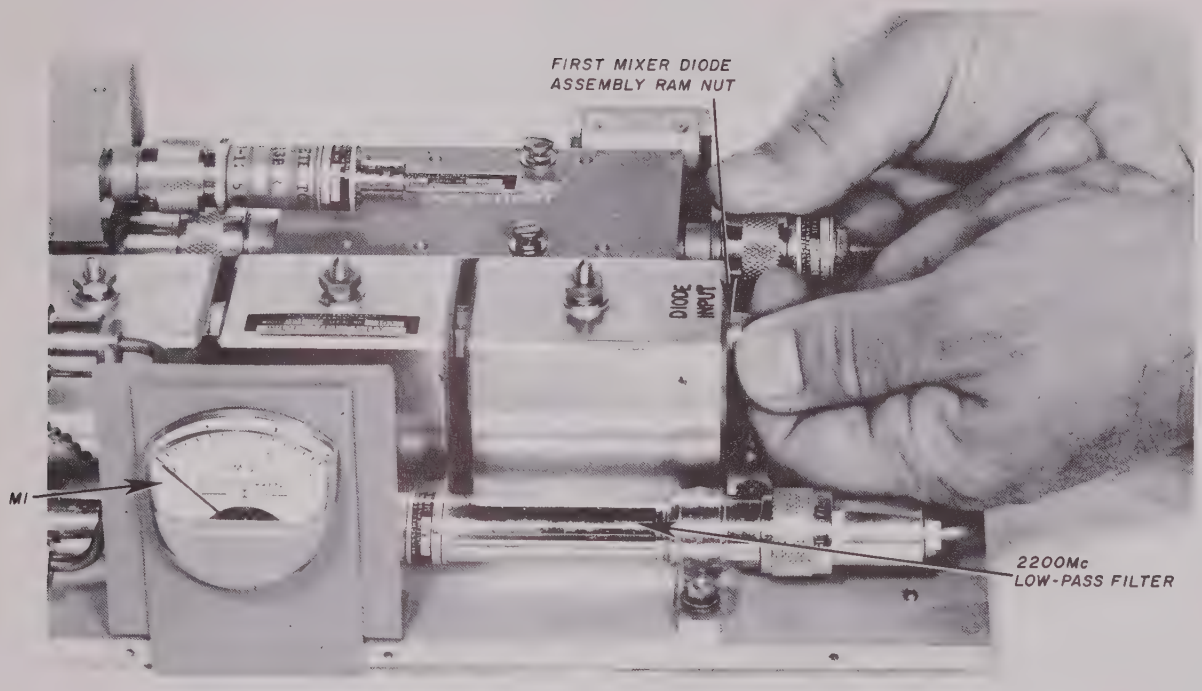

Figure 5.5. First Mixer Diode Assembly Removal

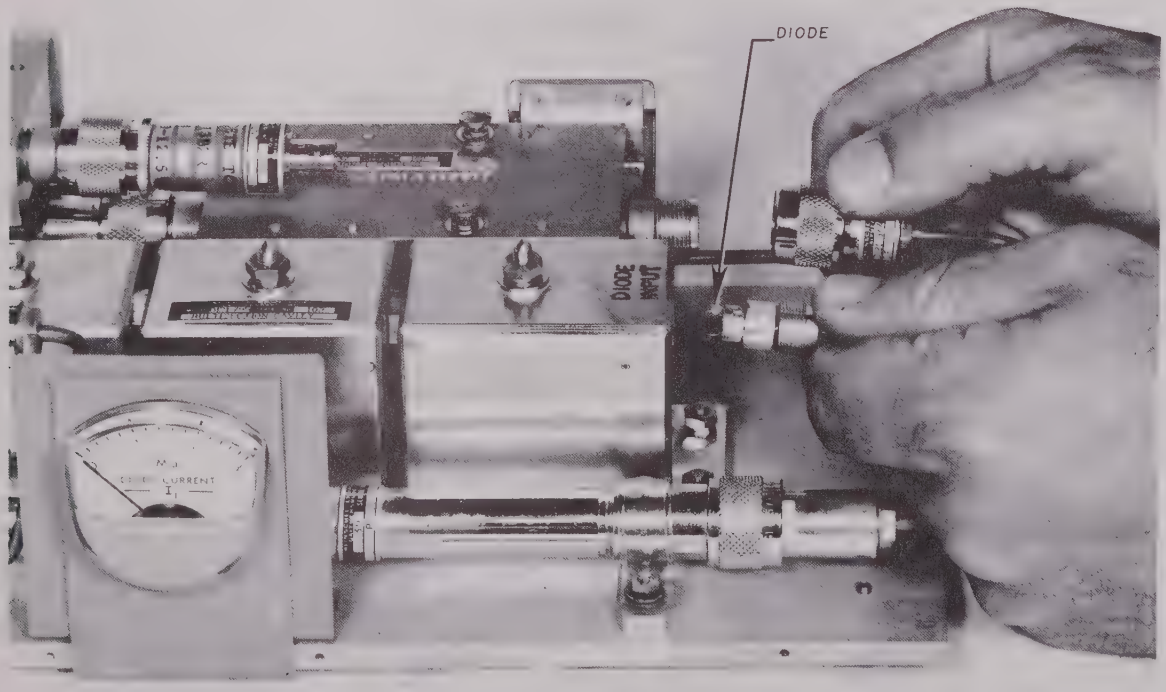

Figure 5.6. First Mixer Diode Assembly Replacement

Follow the procedure outlined in paragraph 5.4.8.

6. After either diode assembly is replaced, follow steps 1 thru 5 in reverse order to reassemble the HO-A mixer module.

5.3 ELECTRICAL

5.3.1 Vacuum Tube Replacement. The Model HO-1 was designed to allow for normal deviations in standard commercial tubes. No special precautions are necessary for replacements, except that they should have normally low noise levels. Whenever a tube is replaced, compliance tests pertinent to the replacement must be performed. See paragraph 5..5.

The Model HO-1 tube complement is shown in table 5-1.

Table 5-1

TUBE COMPLEMENT

Symbol	Type	Use
V-101	5U4	Rectifier
V-102	6AS7	Series Regulator
V-103	6SJ7	Amplifier
V-104	0C3	Voltage Regulator
V-105	5R4	Rectifier
V-106	12BH7	Series Regulator
V-107	6AU6A	Amplifier
V-108	0A2	Voltage Regulator
V-109	6BL6	Tunable Oscillator Klystron
V-110	6X4	Clamp
V-111	6BL6	Fixed Oscillator Klystron
V-112	6X4	Clamp

5.3.2 Klystron Tube Replacement Selection. It has been found in practice that the 6BL6 reflex klystron tubes available from various commercial tube manufacturers exhibit significant differences in interelectrode capacities. This lack of uniformity can significantly affect the calibration accuracy of the HO-1 SIGNAL FREQUENCY dial and the operating frequency of the 2060-mc fixed oscillator. For this reason 6BL6 klystron tubes should be replaced only with high-performance klystrons available from Weinschel Engineering. Each tube has been specially selected for use in the HO-1 and given the Weinschel part number. See Section 6, Parts Lists, for the part number and ordering information.

5.3.3 Replacement of Repeller Tracking Control, R-118.

R-118 is a special-taper potentiometer ganged with the tunable oscillator cavity drive mechanism. The potentiometer arm determines the optimum voltage to the tunable oscillator klystron repeller at each frequency across the band. R-118 is a specially designed precision unit and should be replaced only by an exact duplicate. See the Parts List for the part number and ordering information.

To remove and replace R-118 proceed as follows:

1. Remove the HO-1 from its cabinet.

2. Turn the COARSE TUNING control either way until the SIGNAL FREQUENCY dial drive mechanism is in the limit stop position.

3. Carefully note which leads are connected to each of the terminals of R-118; disconnect the leads.

4. Loosen the two Allen set-screws holding the drive gear to the potentiometer shaft.

5. Remove the drive gear without disturbing the shaft position; note the angular position of the shaft with a grease pencil or scribed line.

6. Using an open-end wrench, remove the locknut holding the control; remove the control.

7. To replace the control, reverse the above procedure. Take care to position the replacement control in the same angular position as noted in step 5. Failure to do so can result in damage to the internal mechanism of the control.

8. After replacement of R-118, the tunable oscillator repeller voltage tracking adjustment procedure must be performed as outlined in paragraph 5.4.4.

5.3.4 Multisection Cavity and Half-Wave Reaction Cavity Adjustments.

The HO-A mixer module was designed with sufficient tolerance in the first diode mixer input circuit to allow for normal deviation in first mixer assembly replacements. Should replacement of the first mixer assembly become necessary, do NOT attempt to optimize performance by adjusting any of the controls on either the 2090-mc multisection cavity or the 2090-mc half-wave reaction cavity. There are adjustments originally made and set at the factory, and should not be disturbed.

If realignment of either the half-wave reaction cavity or the multisection cavity is thought desirable as a result of misuse, damage, malfunction, or deterioration under normal use, return the HO-A mixer module intact to the manufacturer for adjustment.

5.3.5 Electrical Component Replacement.

Electrical components should be replaced with parts listed in Section VI, Parts List. Whenever electrical components are replaced, pertinent alignment procedures and compliance tests should be performed.

5.3.6 115/230 Volt Operation.

The Model HO-1 is designed to operate from either 115 or 230 VAC, 50/60 cps. Unless otherwise specified, the HO-1 was wired and tested for 115-volt operation prior to shipment from the factory. Check the red CAUTION label on the rear apron of the chassis for the proper operational voltage.

Operation at either nominal voltage may be arranged by changing the wiring of terminal strips TS-101 and TS-102 underneath the chassis. See figure 3.2 for location of these terminal strips. Refer to the schematic diagram in the back of this book for wiring arrangement.

For operation at 115 volts, there is a jumper connection between terminals 1 and 2 and between terminals 3 and 4 on each terminal strip. For 230-volt operation, remove the jumpers from these terminals and connect terminals 2 and 3 on each terminal strip. CAUTION: Be sure to change BOTH terminal strips when making a voltage change. DANGER: Be sure the HO-1 power cord is not connected when changing terminal strip connections.

Access to the underside of the chassis is gained by removing the HO-1 from its cabinet, laying it on the panel handles, and removing the bottom plate.

5.4 ELECTRICAL SERVICING

5.4.1 Introduction.

When standard electrical components such as resistors, capacitors, etc., must be replaced, make sure that the replacement is an exact duplicate of the original. Manufacturer's part and model numbers, as well as the Weinschel part number, are given in the parts list, Section VI, for all components. In case of doubt, or inability to obtain the exact replacement for any component, order direct from Weinschel Engineering, Inc., Gaithersburg, Maryland 20760.

Good engineering practices must, of course, be followed in the replacement of any component. A substitute part must be replaced in the same configuration as the original, leads must be made as short as possible, cold-soldered joints must be avoided, etc.

After any component is replaced, measurement and calibration tests of the circuitry involving that component must be performed.

5.4.2 Test Equipment Required.

Test equipment used in all measurement tests must be of the make and model recommended or equal in quality and range. Use of inferior test equipment will most certainly degrade the accuracy of precise measurements.

Table 5-2 lists the test equipment required.

5.4.3 HO-1 Beam and Repeller Voltage Supplies.

Remove the HO-1 from its cabinet. Connect the HO-1 to the 115VAC power line through a 115VAC variac.

5.4.3.1 Beam Voltage Adjustment

1. Connect the DC VTVM between ground and TP-101 with the positive lead to ground. Turn the POWER switch ON; the green indicator light should come on. After 90 seconds the thermal delay relay should close activating the power transformer as indicated when the red H.V. indicator

TABLE 5-2

TEST EQUIPMENT REQUIRED

Equipment	Manufacturer	Model
Variac	General Radio	W10MT3A
AC VTVM	Hewlett-Packard	400D
VSWR Indicator	Weinschel Engineering	1800
VOM	Triplett	630A
Oscilloscope	Tektronix	545
Oscilloscope Plug-In	Tektronix	L
Signal Generator	Hewlett-Packard	608D
Signal Generators	Weinschel Engineering	Listed in table 3-1
Klystron Power Supply (for use with MS-31)	Weinschel Engineering	MO-4
Klystron Cooling Control (for use with MS-31)	Weinschel Engineering	KC-1
50Ω Coaxial Termination	Weinschel Engineering	535MN
Slotted Line	Weinschel Engineering	1000-R
Coaxial Adapter	Weinschel Engineering	F1501-NR
RF Power Meter	Hewlett-Packard	430C
Thermistor Mount	Hewlett-Packard	477B
Thermistor Mount	Hewlett-Packard	X487B
Coaxial-to-Waveguide Adapter (2 required)	Hewlett-Packard	X281A
Slotted Line	Hewlett-Packard	806B
Slotted-Line Probe	Hewlett-Packard	444A
Square-Wave Modulator	Weinschel Engineering	MO-1C
10-db Coaxial Attenuator (3 required)	Weinschel Engineering	2-10
20-db Coaxial Attenuator (3 required)	Weinschel Engineering	2-20
6-db Coaxial Attenuator (2 required)	Weinschel Engineering	2-6
Coaxial Step Standard Attenuator	Weinschel Engineering	2161
Frequency Meter	Hewlett-Packard	536A
Crystal Detector Mount	Weinschel Engineering	578
30-Mc Receiver	Weinschel Engineering	VM-3 Attenuator and Signal Calibrator
10-Db Variable Coaxial Attenuator	Weinschel Engineering	973
DC VTVM	Triplett	650

light comes on.

2. Set the variac to 115 VAC. Allow five minutes for complete stabilization, then adjust R-105 until the DC VTVM indicates exactly 325 volts. Lock R-105.

5.4.3.2 Beam Voltage Stability Test

1. Decrease the line voltage from 115VAC to 105VAC with the variac. There should be minimal change (less than a pointer width) in the DC VTVM indication.

2. Increase the line voltage to 125VAC. Again there should be minimal change in the DC VTVM indication. Turn OFF the HO-1 and disconnect the DC VTVM.

5.4.3.3 Beam Voltage Ripple Test

1. Connect an AC millivoltmeter through a well shielded cable with the hot lead to TP-101 and the shield to ground. Turn ON the HO-1. With the millivoltmeter in the broadband position, the indication should be less than 15 mV rms.

2. Vary the line voltage between 105VAC and 125VAC. The ripple voltage should never exceed 15 mV rms. Turn OFF the HO-1 and disconnect the millivoltmeter.

5.4.3.4 Repeller Voltage Adjustment

1. Connect the DC VTVM with the positive lead to TP-101 and the negative lead to TP-102. Turn ON the HO-1. After five minutes, adjust R-114 for an indication of exactly 560 volts. Lock R-114.

5.4.3.5 Repeller Voltage Stability Test

1. Decrease the line voltage from 115VAC to 105VAC. There should be no noticeable change in the DC VTVM indication.

2. Increase the line voltage to 125VAC. Again there should be no noticeable change in the DC VTVM indication. Turn OFF the HO-1 and disconnect the DC VTVM.

5.4.3.6 Repeller Voltage Ripple Test

1. Connect the AC voltmeter through a 2-μf 1000-V paper capacitor to TP-102. Connect the shield to ground. Turn the HO-1 ON. With the AC voltmeter in the broadband position, the indication should be less than 15 mV rms.

2. Vary the line voltage between 105VAC and 125VAC. The ripple voltage should never exceed 15 mV rms. Turn OFF the HO-1 and disconnect the AC voltmeter.

5.4.3.7 Klystron Beam Current Adjustments

1. Make sure the HO-1 POWER switch is OFF. Disconnect the jumper wire between TP-103 and TP-104.

2. Connect a 0-50 DC milliameter between the test points with the plus side of the meter to TP-103. Note that when connected thus, the meter will indicate the sum of both klystron beam currents, plus 6 ma of bleeder current.

3. To adjust the beam current of V-109, the tunable oscillator, disconnect terminals 13 and 14, of TS-103. Turn the HO-1 POWER switch ON, observe the milliameter, and adjust R-119 for an indication of approximately 26 ma. Lock R-119. Reconnect terminals 13 and 14 of TS-103.

4. To adjust the beam current of V-111, the fixed oscillator, disconnect terminals 1 and 2 of TS-103. Adjust R-128 until the milliameter indicates approximately 26 ma. Lock R-128. Reconnect terminals 1 and 2 of TS-103. Remove the milliameter and replace the jumper connection between TP-103 and TP-104. Take care not to short-circuit other terminal connections.

5.4.4 Tunable Oscillator Repeller Voltage Tracking Adjustment

1. Set up the equipment as shown in figure 5.7.

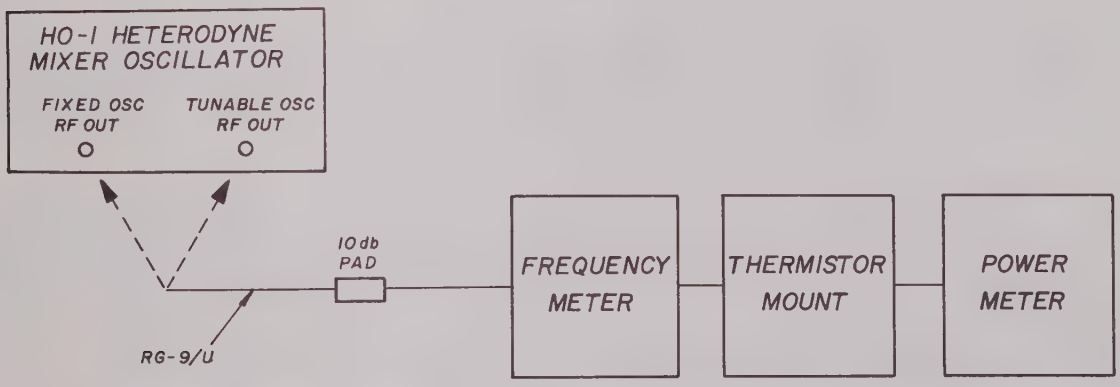

Figure 5.7. HO-1 Power Output and Frequency Measurement Test Setup

2. Make sure the HO-1 POWER switch is OFF. Make sure the AFF switch is OFF. Make sure the attenuator is connected to the RF OUT jack of the tunable oscillator.

3. Connect a DC VTVM with the negative lead to terminal 4 of TS-103 and the positive lead to TP-101. Turn the HO-1 POWER switch ON. Set the FINE TUNING control to the center of its range.

4. Set the dial to 4100 mc and adjust R-123 for maximum output power as indicated on the voltmeter.

5. Set the dial to 2000 mc and adjust R-121 for maximum output power, approximately -20 volts. Figure 5.8 shows performance curves of the tunable oscillator power output and frequency as a function of the repeller tracking voltage.

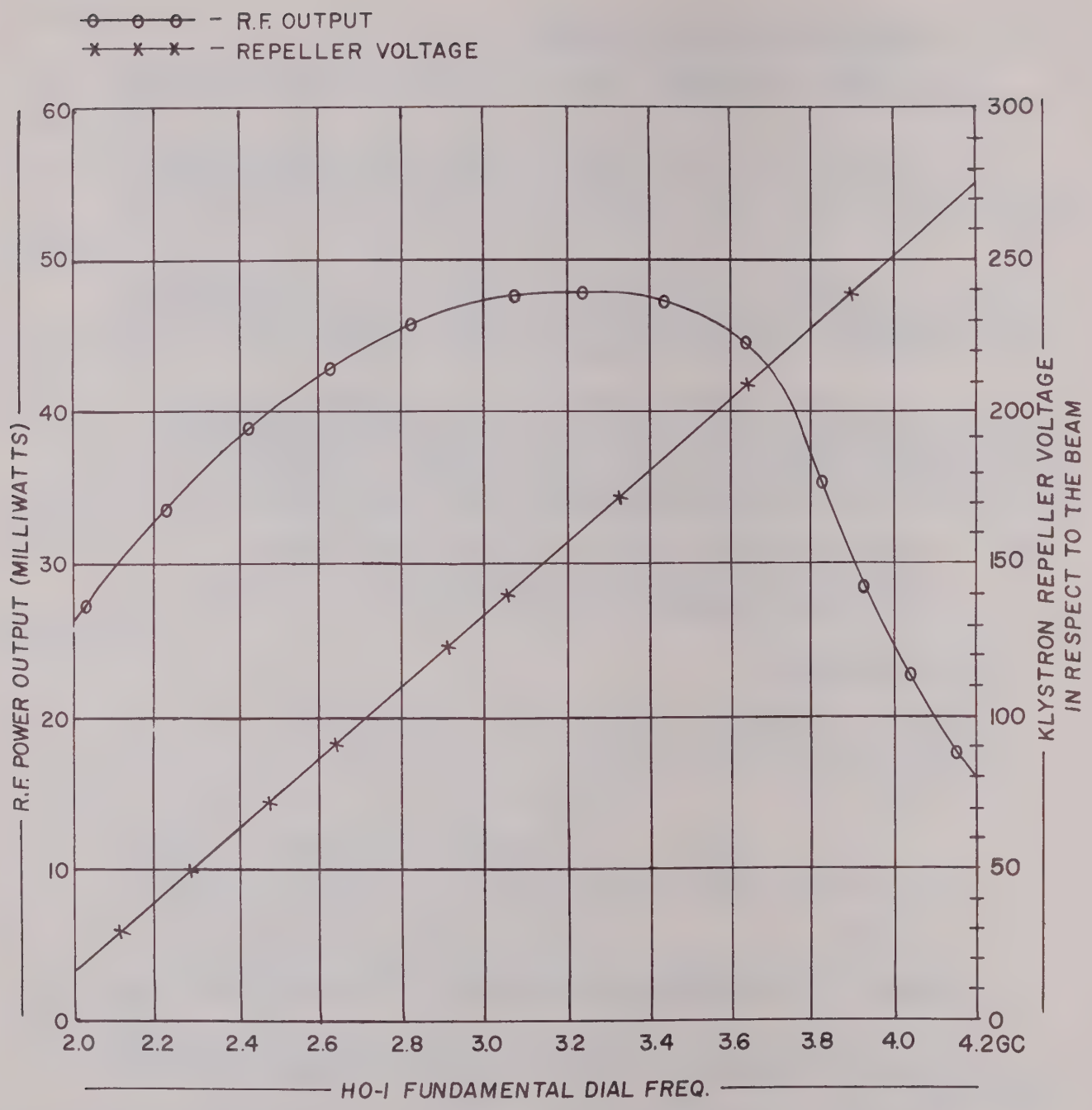

Figure 5.8. Nominal Tunable Oscillator RF Power Output and Repeller Tracking Voltage Vs. Dial Frequency

6. Vary the HO-1 COARSE FREQUENCY control throughout its entire frequency range while observing the RF power output. RF power output should be realized across the entire HO-1 frequency band from 2020 to 4200 mc with the HO-1 FINE TUNING control in its mid-position.

If continuous operation is not obtained, readjust the angular position of the tracking pot as required and repeat steps 4 and 5. Ultimately continuous RF operation will be obtained so that the HO-1 FINE TUNING control is capable of peaking the RF output signal everywhere in the band without being physically limited by the stop positions at either end of rotation.

5.4.5 Fixed Oscillator Preliminary Power Output Adjustment

1. Use the same setup as shown in figure 5.7 above, with the attenuator connected to the FIXED oscillator RF OUTPUT jack.

2. Carefully loosen the fixed oscillator output probe locknuts.

3. Adjust the probe depths for an RF power output of approximately 2 milliwatts maximum as indicated on the RF power meter. Tighten the probe locknuts. NOTE: RF power output can go as high as 60 mW, depending on the depth of the probe, so take care!

5.4.6 Fixed Oscillator Preliminary Frequency Adjustment

1. Use the same setup as shown in figure 5.7 above, with the attenuator connected to the fixed oscillator RF OUTPUT jack. Place the negative lead of the DC voltmeter on terminal 5 of TS-103, and the positive lead on TP-101. Turn the HO-1 POWER switch ON and allow five minutes for warmup.

2. Adjust the output frequency of the oscillator to 2060 mc ±1/2 mc using the tuning screw; simultaneously adjust R-135 to maximize the output as the frequency is adjusted, approximately -170 volts as indicated on the voltmeter.

3. Tighten the locknuts on the tuning screw and on R-135. Recheck the frequency indication. For best results, the HO-1 oscillator module should be in an enclosed instrument housing so that all components will have reached their final operation ambient temperature before removing the HO-1 from its cabinet to make these adjustments.

5.4.7 Fixed Oscillator Final RF Output Level and Frequency Adjustment.

Remove the HO-1 from its cabinet and set up the required equipment for dual conversion operation as shown in figure 4.3. Use an HP612A signal source.

1. Connect the fixed oscillator output cable W2 to J5 of the HO-A mixer. Loosen the knurled locknut securing the fixed oscillator coupling loop assembly and adjust the loop until 0.8 ma of diode current is indicated on the VM-3 main meter. Avoid excessive diode current during this adjustment. Lock the probe in its final position.

2. Detect and capture a -20 to -30 dbm 1000-mc input signal to the HO-1/VM-3 as outlined in paragraph 4.5.5.

3. Turn the METER FUNCTION switch to the RECEIVER OUTPUT position and adjust the RECEIVER GAIN control for a mid-scale indication on the main

meter. Note the db level indication on the VM-3 main meter. Loosen the locknut securing the cavity tuning screw in the side of the fixed oscillator cavity. This screw is rotated to adjust the frequency of the fixed oscillator.

4. Alternately adjust the frequency of both the RF signal source and the fixed oscillator until the maximum upscale deflection is observed on the main meter; lock the cavity tuning screw in this position. Also be sure to maintain the proper FREQUENCY DEVIATION meter zero indication during this procedure.

5. To optimize the frequency setting of the fixed oscillator, the FIXED OSC. FINE TUNING control, R-135, on the rear apron of the chassis should be adjusted. Follow the procedure described in step 4 using R-135 to vary the fixed oscillator frequency, and lock the control when the procedure is completed.

6. Steps 4 and 5 above may affect the diode current I_2; it may be necessary to repeat step 1 to reestablish a diode current of 0.8 ma.

5.4.8 2090-Mc IF Tuner Adjustment.

The 2090-mc IF tuner is provided in the HO-A mixer module to maximize the RF power transfer from the output of the first mixer circuitry to the input of the second mixer diode in the dual conversion mode of operation. This adjustment should be made whenever the second mixer diode assembly is replaced, or whenever system performance deterioration is suspected traceable to this adjustment.

1. Remove the cover of the HO-A.

2. Replace the 30-mc IF matching network control knob and tighten the setscrews.

3. Remove the four screws securing the cover plate of the 2090-mc IF tuner. See figure 3.4.

4. Interconnect the HO-1 for operation in the dual conversion mode and follow the HO-1 equipment setup procedure outlined in paragraph 4.4.1.

5. Use a CW or 1000-cps modulated signal at any output frequency between 10 mc and 1990 mc. Adjust the RF input to the HO-A to a level of -25 to -35 dbm.

6. Detect and capture the input signal following the entire procedure outlined in paragraph 4.5.4, 4.5.5, 4.5.6, whichever is applicable.

7. With the input signal detected, loosen the setscrews on the movable slugs within the 2090-mc IF tuner assembly, and vary the slug positions until a maximum power transfer is observed on the receiver output display.

8. Lock the tuning slugs in position with the setscrews. Replace the cover plate with the four screws provided.

5.4.9. SIGNAL FREQUENCY Dial Adjustment.

Should it become necessary to adjust the HO-1 SIGNAL FREQUENCY dial, as in the case of tunable oscillator klystron tube replacement, proceed as follows:

1. Interconnect the HO-1/VM-3 as in the dual conversion setup as shown in figure 4.3, but do not connect a signal source.

2. Remove the HO-1 from its cabinet.

3. Set the SIGNAL FREQUENCY dial to approximately 2060 mc and follow the procedure outlined in paragraph 4.4.1. After completing step 6, turn the LEVEL ADJ. control fully clockwise so that I_1 drops to a very low value.

4. Follow the procedure outlined in paragraph 4.5.3 starting with step 4. The strong signal indication displayed on the VM-3 main meter is the detected 2090-mc tunable oscillator output passing through the multisection cavity. This detected signal will be used to aid in setting the dial.

5. Without disturbing the detected signal, carefully unlock the clamp holding the dial to the COARSE TUNING control drive shaft. See figure 5.1.

6. Rotate the dial until the 2.06 mark coincides with the hairline in the dial window. Lock the clamp without disturbing the dial setting or the detected signal. The SIGNAL FREQUENCY dial is now properly adjusted for all modes of operation.

5.4.10 Input VSWR of First Mixer at Signal Frequencies.

Set up the required equipment as shown in figure 5.9.

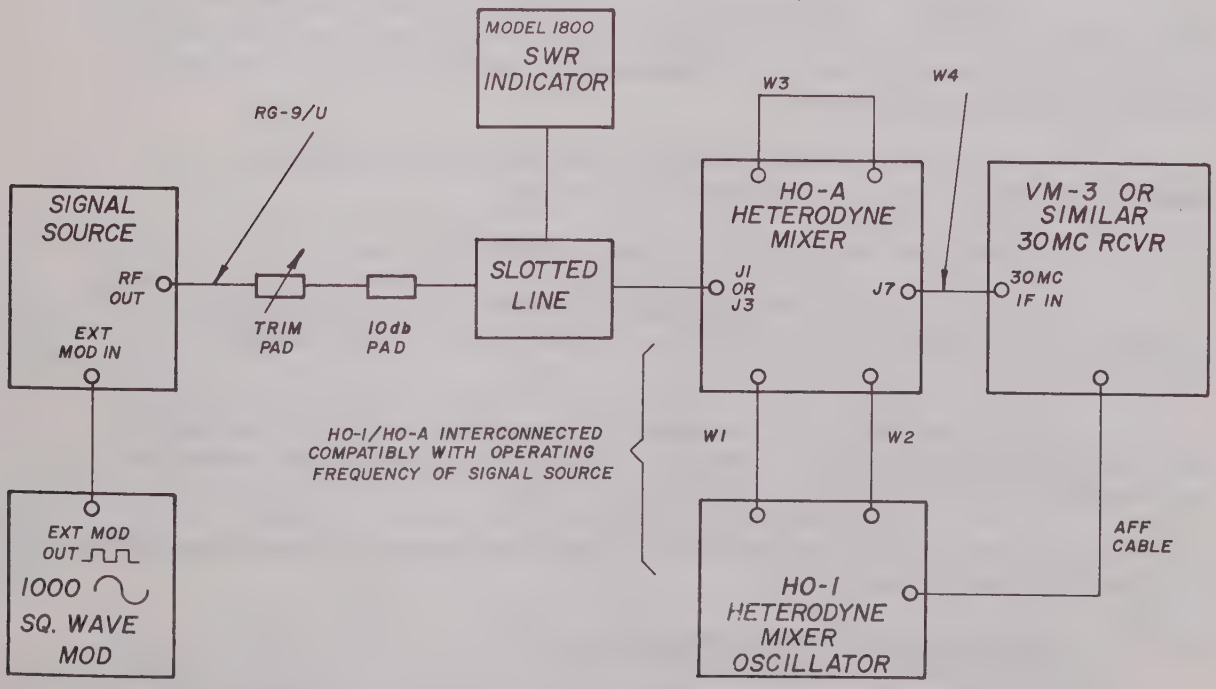

Figure 5.9. HO-A Input VSWR Test Setup

1. Adjust the signal source RF output power level for a maximum RF power input of -15 dbm at the HO-A signal input jack J1. Take great care to adjust the power level properly; input power in excess of 2 mw (+3 dbm) may damage the mixer diode.

2. With the signal source and the HO-1 tuning dial set to the same frequency, adjust the LEVEL ADJ. control until the first mixer current I_1 is 1.8 ma. This current will be monitored on the HO-A milliameter M1. I_2 should be 0.75 ma to 0.85 ma.

3. Adjust the probe tuning on the slotted line until a readable indication is seen on the SWR meter. Measure the J1 input VSWR from 500 mc to 2000 mc. When making measurements, set the HO-1 frequency dial to the measurement frequency.

4. If the input VSWR exceeds 3:1, vary the diode current, I_1, between 1.6 and 1.9 ma using the LEVEL ADJ. control, until the lowest VSWR is obtained. Typically the input VSWR in this frequency range should be lower than 3.5:1.

5.4.11 Input VSWR of Second Mixer at Signal Frequencies.

Set up the required equipment as shown in figure 5.9.

1. Adjust the signal source RF output power level for a maximum RF power input of -15 dbm at the HO-A signal input jack J3. Take great care to adjust the power level properly; input power in excess of 2 mw (+3 dbm) may damage the mixer diode.

2. With the signal source and the HO-1 tuning dial set to the same frequency, adjust the LEVEL ADJ. control until the mixer current I_2 is either 0.8 ma for fundamental frequency measurements, or 2.1 ma for harmonic frequency measurements.

3. Adjust the probe tuning on the slotted line until a readable indication on the SWR meter is obtained.

4. Measure the input VSWR from 2 gc to 12.4 gc.

5. If the input VSWR exceeds 3:1 in the 2-4 gc region, vary the LEVEL ADJ. control slightly (0.7 to 0.9 ma) until the lowest VSWR is obtained.

6. If the input VSWR exceeds 3.5:1 in the 4-12.4 gc region, vary the LEVEL ADJ. control slightly (2.0 to 2.2 ma) until the lowest VSWR is obtained.

7. Typically, the input VSWR over the frequency range from 2-12.4 gc should be lower than 4.0:1.

5.4.12 HO-A Conversion Loss Measurements.

To determine the conversion loss of the HO-A heterodyne mixer at any frequency from 10 mc to 12.4 gc, proceed as follows:

1. Select the operating mode of the HO-1 to be compatible with the signal source selected for the conversion loss measurement to be made. Follow the appropriate setup procedure in paragraph 4.4.

2. Set up the equipment as shown in figure 4.2 or 4.3, except that the RF source is operated CW and connected directly to the HO-A signal input through a 10- or 20-db attenuator and double-stub tuner as required.

3. Detect and capture the input signal as outlined in paragraph 4.5.3, but adjust the VM-3 TUNING control and the 30-mc IF matching network for maximum receiver output indication, omitting step 7 from the procedure.

4. Adjust the RF signal level to the HO-A input to establish a -35 dbm signal level.

5. Readjust the VM-3 STANDARD ATTENUATOR controls until the AMPLITUDE BALANCE meter is centered. Record the db setting of the optical readout.

6. Reconnect the VM-3 and associated equipment as shown in figure 5.10.

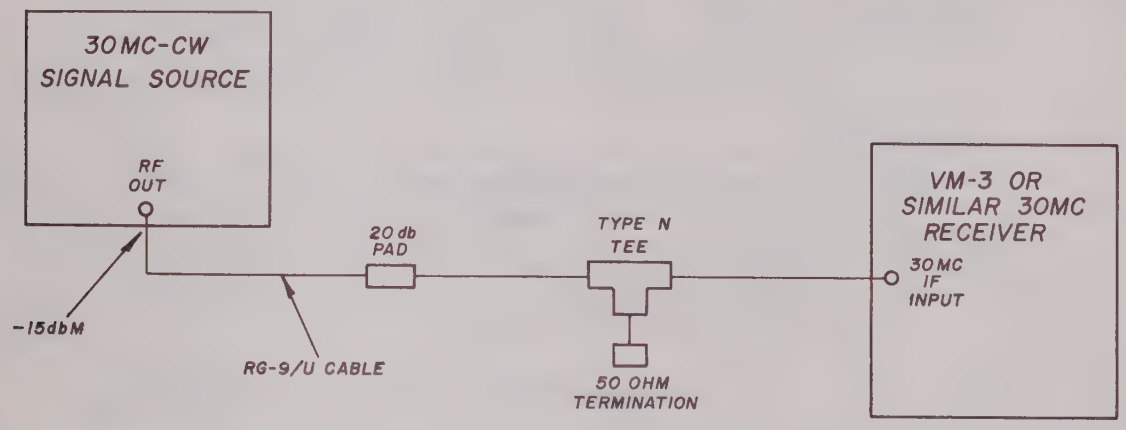

Figure 5.10. Conversion Loss Test Setup

7. Adjust the signal generator to achieve essentially zero RF signal output at 30 mc, with the HP608 internal attenuator set at 130 db or more, or break the signal path at the generator side of the pad. Reset the AFF control on the VM-3 to OFF and the FUNCTION SELECTOR switch to the ATTENUATION MEASUREMENT CW position. Adjust the STANDARD ATTENUATOR COARSE control to maximum, about 140 db. Adjust the ZERO SIGNAL BALANCE and TUNING controls to center the AMPLITUDE BALANCE and FREQUENCY DEVIATION meters. Reset the STANDARD ATTENUATOR to approximately 30 db and adjust the signal generator 30 mc cw output to -15 dbm. Slightly readjust the frequency of the signal generator output, if necessary, until the FREQUENCY DEVIATION meter is centered. Readjust the STANDARD ATTENUATOR controls until the AMPLITUDE BALANCE meter is centered. Record the db setting of the optical readout.

8. To obtain the db conversion loss of the mixer, add 4 db (reflection loss between 400 ohms and 50 ohms) to the db setting recorded in step 5, and subtract from this sum the db indication recorded in step 7. The resulting number is the conversion loss in db of the mixer. Typically,

the conversion loss should be approximately 8 db, 15 db, 17 db, and 20 db in the fundamental, second harmonic, third harmonic, and dual conversion modes, respectively.

5.4.13 3-Db Bandwidth Measurement -- Multisection Cavity.

Set up the required equipment as shown in figure 5.11.

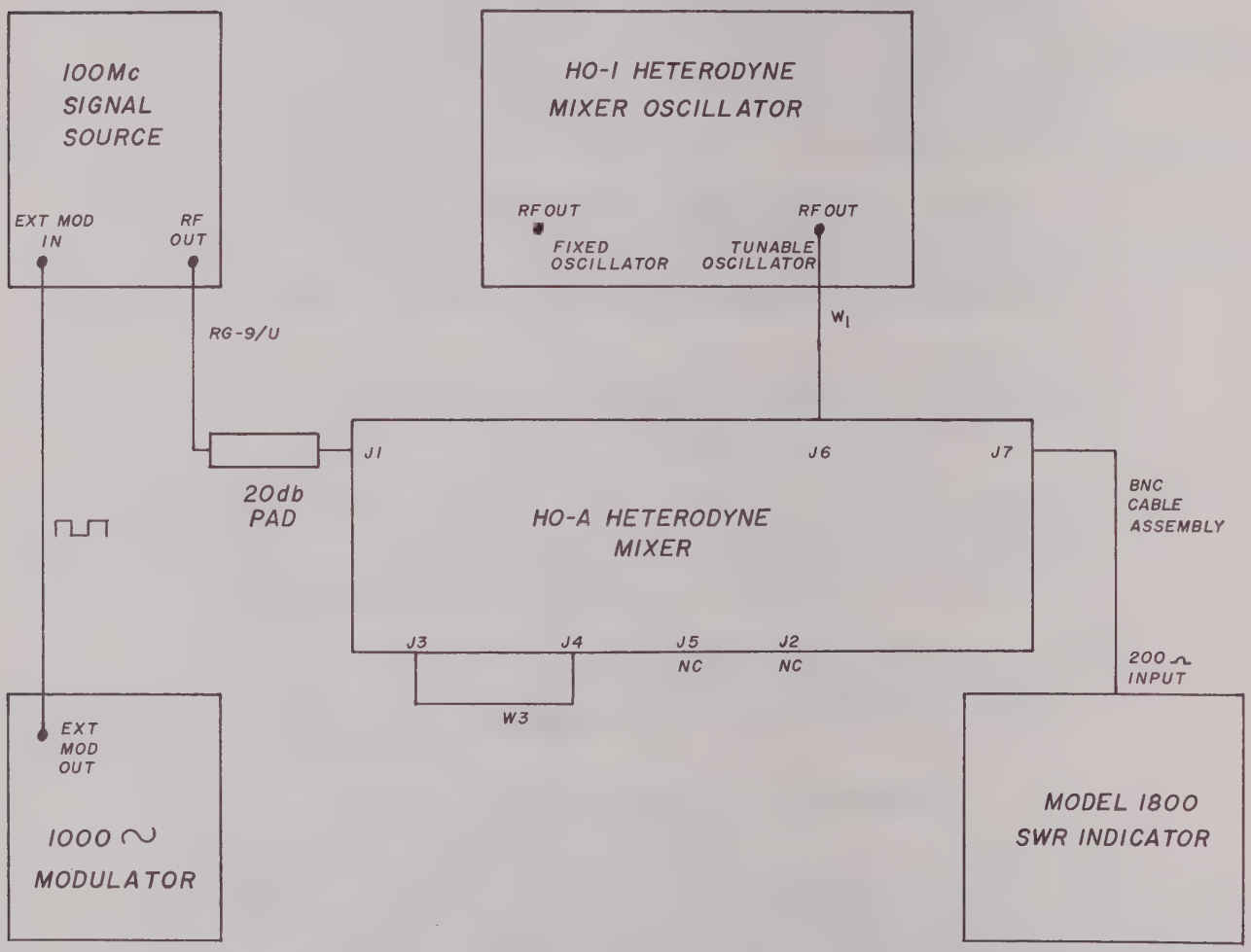

Figure 5.11. HO-A Multisection Cavity Bandwidth Measurement Setup

1. Turn the HO-1 AFF switch OFF. Allow at least five minutes warmup time before starting measurement procedures.

2. Adjust the signal source frequency and the SIGNAL FREQUENCY dial to 100 mc.

3. Adjust the signal source for 1000-cps square-wave modulation and a -15 dbm RF power input to the HO-A at the signal input jack J1.

4. Vary the HO-1 LEVEL ADJ. control until the first diode mixer current I_1 is 1.75 to 1.85 ma.

5. Vary the COARSE TUNING control until a peak is detected on the VSWR meter; adjust the VSWR amplifier gain for a full-scale meter deflection.

6. Vary the frequency of the signal source until a 3-db decrease in signal strength is noted either side of 100 mc. Note the frequency of the signal source at each 3-db point. The difference in frequency between the two 3-db settings of the dial is the 3-db bandwidth of the 2090-mc multisection cavity, and is approximately 4 mc.

5.5 SPECIFICATION COMPLIANCE TEST PROCEDURES

Compliance tests verify that the equipment is still performing according to the specifications listed in table 1.1. These tests should be performed every six months or whenever an electrical component is replaced. The equipment should be allowed to warm up for at least one hour before these tests and measurements are made.

5.5.1 Tunable Oscillator RF Power Output Measurement.

1. Use the same setup as in figure 5.7 with the attenuator connected to the TUNABLE oscillator RF OUTPUT jack. Turn the LEVEL ADJ. control on the front panel to the fully ccw counterclockwise position corresponding to maximum output power.

2. Turn the HO-1 POWER switch ON, and tune the COARSE TUNING control over the entire range while observing the RF power meter. Adjust the FINE TUNING control for maximum RF output. The RF output power indicated should be greater than 5 milliwatts over the frequency band from 2020 to 2090 mc and greater than 15 mW from 2090 mc to 4200 mc. If it is not, realignment or replacement of the tunable oscillator klystron tube will be necessary.

5.5.2 Tunable Oscillator Frequency Measurement.

1. Set up the equipment as shown in figure 5.7 with the test equipment connected to the tunable oscillator RF OUTPUT jack.

2. Set the HO-1 dial to the test frequency.

3. Adjust the FINE TUNING control to peak the RF power output.

4. Vary the LEVEL ADJ. control until 5 to 20 mW is indicated on the power meter.

5. Check the calibration of the dial against the frequency as indicated on the wavemeter. The difference should be less than 1% at all points.

NOTE

> The HO-1 dial has been precalibrated to indicate 30 mc below the oscillator frequency on the FUNDAMENTAL scale. Be sure to keep this in mind when checking dial accuracy against actual oscillator frequency.

5.5.3 Smallest Usable RF Input Signal Measurement.

1. Set up the required equipment as shown in figure 5.12.

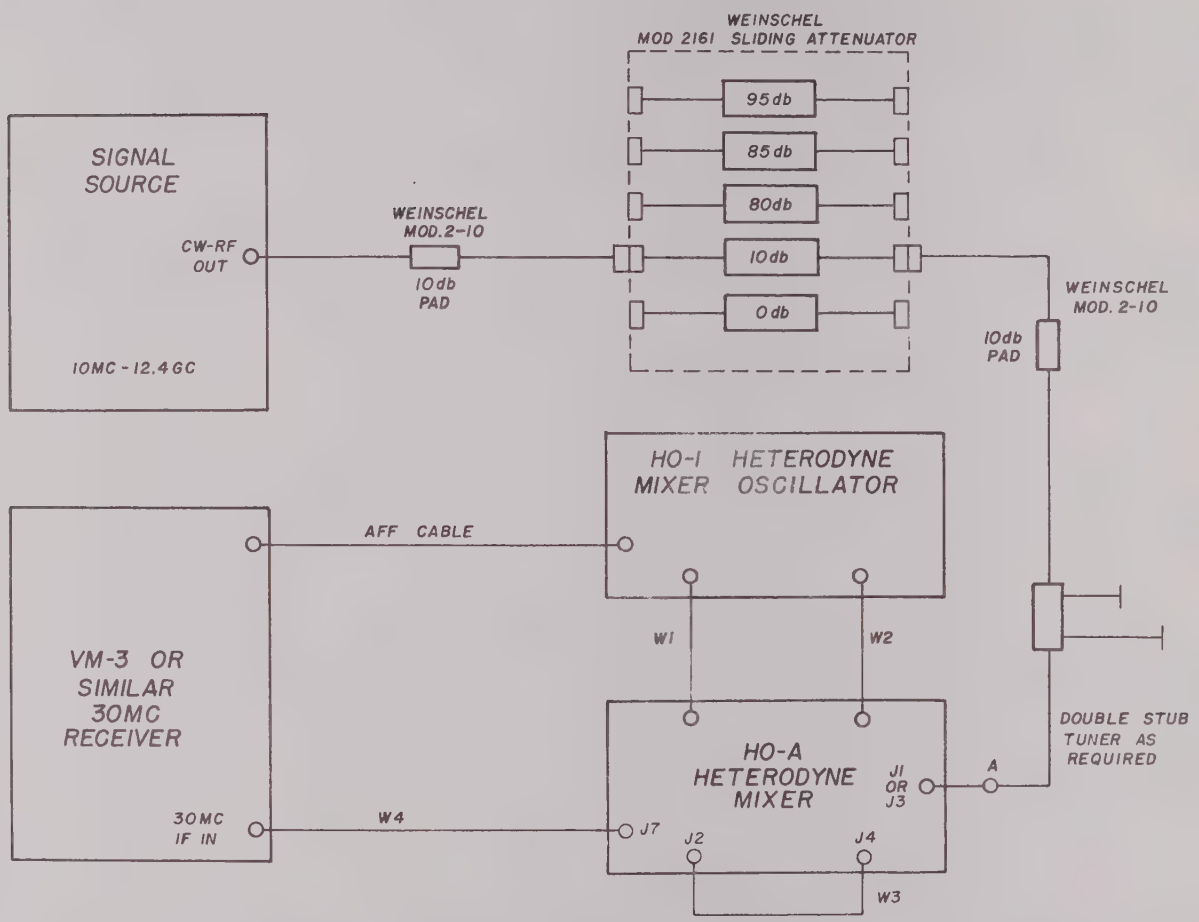

Figure 5.12. Sensitivity and Dynamic Range Measurement Setup

NOTE

The attenuators shown in figure 5.12 should be calibrated as a combined unit and the true step attenuation values of the Model 2161 used as the attenuation standard against which the HO-A mixer operation can be checked.

2. Adjust the model 2161 attenuation standard to the 0-db position and follow the setup procedure outlined in paragraph 4.5.3 omitting step 2.

3. With the HO-1/VM-3 properly adjusted, reduce the RF input signal level to the HO-A input until it is 10 db greater than the "Smallest Usable RF Signal" level as shown in the system specification, paragraph 1.3. Measure and record the attenuation value of the Model 2161 attenuator between the 10-db and 0-db positions.

4. Follow the attenuation measurement procedure as described in paragraph 4.5.3 step 11. The measured value of the 10-db pad should deviate by no more than 0.5 db from its known true attenuation value.

5.5.4 Dynamic Range Measurement -- HO-1/VM-3.

1. Follow steps 1 and 2 of the procedure outlined in the preceding paragraph.

2. With the HO-1/VM-3 properly adjusted, readjust the RF input signal level at the HO-A input to -15 dbm.

3. Measure and record the attenuation value of the Model 2161 attenuator between the 0-db and N-db position, following the attenuation measurement procedure as described in paragraph 4.5.3. N db is equal to the pertinent db value as listed in the system specification paragraph 1.3 under "Dynamic Range". The measured value of the pertinent N-db pad should deviate by no more than 0.5 db from its known true attenuation value.

5.5.5 Incidental FM Measurement, Fixed and Tunable Oscillators.

Set up the required equipment as shown in figure 5.13. Connected in this manner, the HO-1 fixed oscillator output or its harmonic, constitutes a signal input to the HO-A and, as such, is detectable on the HO-1 FUNDAMENTAL frequency scale. Once detected by the HO-1/VM-3 system, the FM measurement circuit within the VM-3 is used as described below to evaluate the incidental FM present in the HO-1 fixed and tunable oscillator outputs.

1. Adjust the variac for 115VAC.

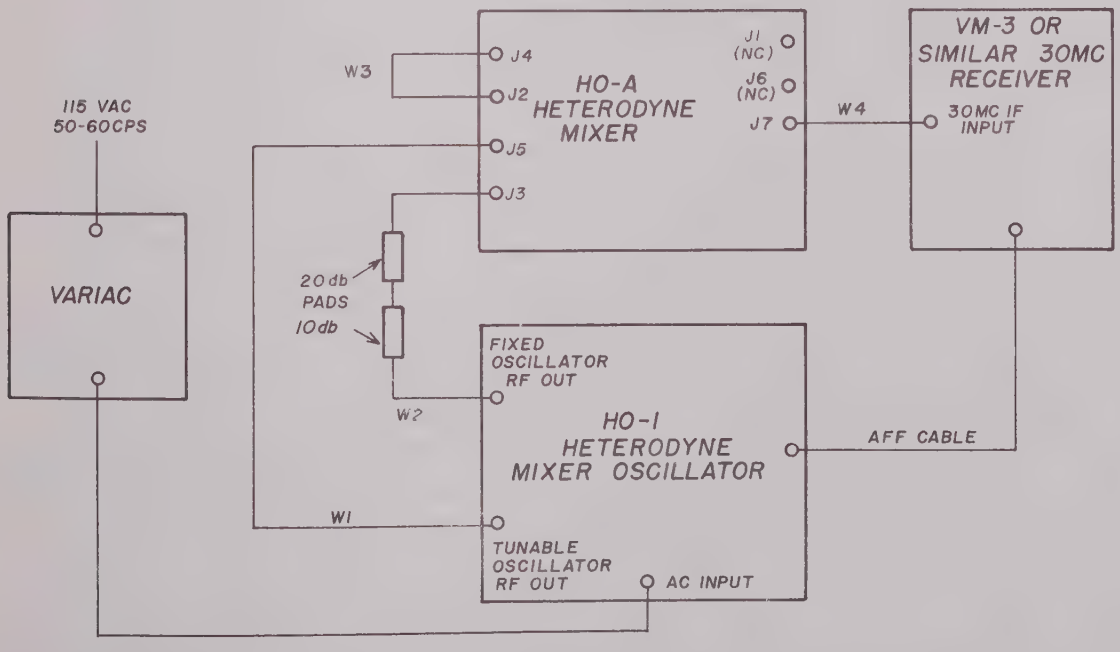

Figure 5.13. Setup for Incidental FM Measurement and Fixed Oscillator Amplitude Stability Test

2. Set the FUNDAMENTAL frequency scale to 4120 mc and adjust the HO-1 and VM-3 as outlined in paragraph 4.4.2 and steps 4, 5, and 6 of paragraph 4.5.3. I_1 should equal to 0 ma, and I_2 should equal approximately 0.8 ma.

3. Turn the VM-3 AFF switch OFF, and the METER FUNCTION switch to RECEIVER OUTPUT. Turn the FUNCTION SELECTOR switch to RECEIVER CW and adjust the RECEIVER GAIN control as required for a mid-scale indication on the main meter.

4. Press the DEPRESS FOR ZERO ADJUST button and set the output meter to zero with the ZERO ADJUST knob.

5. With the FUNCTION SELECTOR switch in the FM MEASUREMENT position, the METER FUNCTION switch in the CAL position, and the POS-NEG switch (red knob) in the NEG position, turn the ADJUST FOR F.S. switch for full-scale deflection on the output meter.

6. Turn the METER FUNCTION switch to the 100 Kc FM position and read the peak-to-peak FM on the output meter. Be sure to monitor the FREQUENCY DEVIATION meter to make sure the input frequency is properly set when the final FM reading is taken.

7. Reset the SIGNAL FREQUENCY dial to 2060 mc on the FUNDAMENTAL scale and repeat the entire procedure described above.

NOTE

The incidental FM measured should be less than 18 kc at 2060 mc and 4120 mc. Since the VM-3 cannot distinguish between the FM from the fixed or tunable oscillator, the incidental FM measurement results should be used only as a figure of merit to establish the electrical acceptability of the HO-1 system.

5.5.6 Fixed Oscillator RF Amplitude Stability.

Set up the required equipment as shown in figure 5.13.

1. Adjust the variac for 115VAC.

2. Set the SIGNAL FREQUENCY dial to 2060 mc on the FUNDAMENTAL scale and adjust the HO-1 and VM-3 as outlined in paragraphs 4.4.2 and 4.5.3. I_1 should equal 0 ma and I_2 should equal 0.75 to 0.85 ma.

3. Allow a one-hour warm-up period before amplitude measurements are made. Set the TIME CONSTANT control fully counterclockwise. Set the SENSITIVITY control between twelve and three o'clock.

4. With the signal properly detected and captured, the system is setup to make RF amplitude stability measurements. Carefully adjust the STANDARD ATTENUATOR for an amplitude balance and record the indication of the optical readout. Wait exactly two minutes and readjust the STANDARD ATIENUATOR and record the new indication of the optical readout. The measured difference between successive readings should be less than 0.02 db.

5. After completing the above measurements, do not change any control setting. Use the variac to set the line voltage to values between 105 and 125 volts. Adjust the STANDARD ATTENUATOR for an amplitude balance at each voltage. Be sure to wait a moment after each line voltage change to allow the HO-1 to stabilize. Record the optical readout indication after each voltage change. The measured difference between successive readings for a 10% change in line voltage should be less than 0.11 db.

5.5.7 Tunable Oscillator RF Amplitude Stability Test.

Set up the required equipment as shown in figure 5.14.

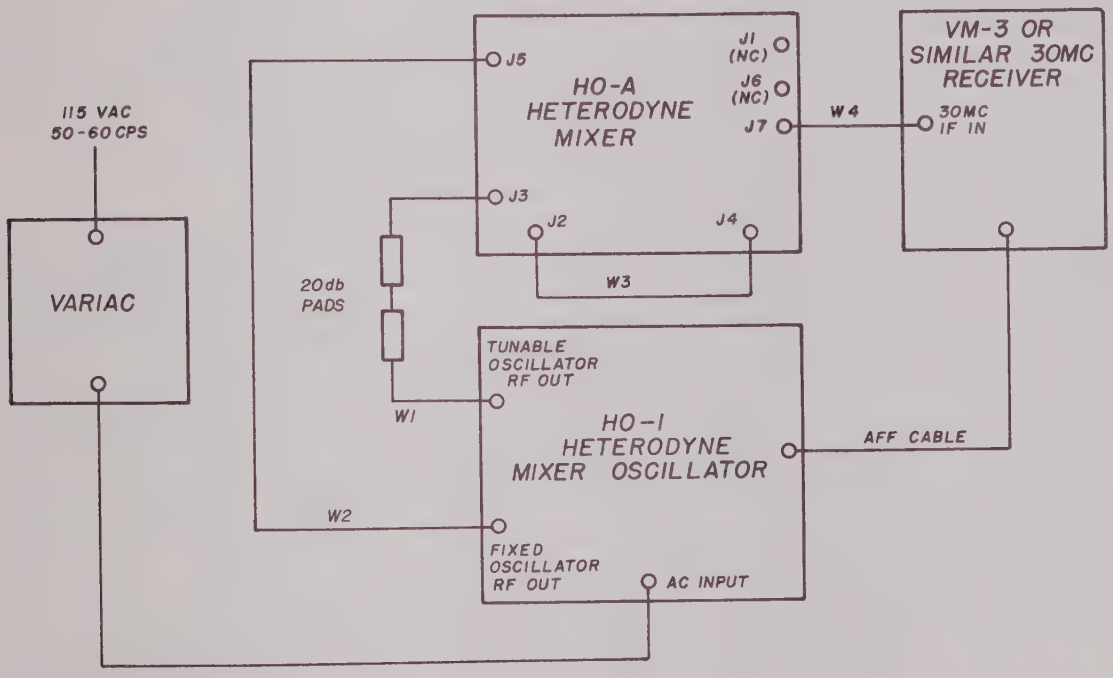

Figure 5.14. Tunable Oscillator Amplitude Stability Test Setup

1. Adjust the variac for 115VAC.

2. Set the SIGNAL FREQUENCY dial to 2060 mc on the FUNDAMENTAL scale and adjust the HO-1 and VM-3 as outlined in paragraphs 4.4.2 and 4.5.3. I_1 should equal 0 ma and I_2 should equal 0.75 to 0.85 ma.

3. Turn the LEVEL ADJ. control clockwise approximately one turn from the fully counterclockwise stop position. Leave the control in this position throughout the test procedure.

4. Follow the procedure as outlined in steps 3, 4 and 5, in preceding paragraph, 5.5.6.

TABLE 5-3

TROUBLE-SHOOTING CHART

Symptom	Possible Trouble	Suggested Check and/ or Remedy
Instrument Dead, Pilot Light Does Not Come On.	Blown Fuse, F101 or F-102	Replace
	Defective thermal delay relay, K102	Replace
	Poor AC Supply Connection	Check Power Connections
Unstable Power Supply Regulation or Excessive Ripple	Defective Regulator tubes (V102, V103, V104, V106, V107, V108)	Replace
	Low Line Voltage	Increase
No High Voltage	Defective Rectifier (V101, V105)	Replace
Decreased Dynamic Range or System Sensitivity (See paragraph 1.3, "Dynamic Range" and "Smallest Usable RF Signal")	Improper Signal Input Level to HO-A	Use RF Power Meter to Establish Proper Signal Input Level
	Spurious Signal Input (Leakage)	Eliminate Source (see paragraph 4.5.3 step 12)
	HO-1/VM-3 Receiver and AFF Function not properly Adjusted.	Adjust VM-3 AFF Gain and Equalization Controls
	Unstable RF Signal Source	Replace
	Fixed Oscillator Frequency Deviation	Measure Frequency of Fixed Oscillator (2060mc) Readjust an Required
	Defective First or Second Diode Mixer	Check Input VSWR at J1 or J3; Check Conversion Loss; replace first or second diode mixer assembly as required.
	Defective Component in HO-A	Check input VSWR at J1 or J3; check conversion loss; check 3-db bandwidth of multisection cavity;return HO-A to Weinschel for repair.
Excessive conversion loss in fundamental and/or harmonic modes	Defective second diode mixer	Measure input VSWR at J3; replace second diode mixer assembly.

TABLE 5-3 (Cont'd)

Symptom	Possible Trouble	Suggested Check and/ or Remedy
Excessive conversion loss in dual conversion mode	Fixed Oscillator Frequency Deviation	Measure frequency of fixed oscillator (2060mc) Readjust as required
	Deterioration of multi-section cavity tuning	Check 3-db bandwidth
	Defective first diode mixer	Measure input VSWR at J1; replace first mixer diode assembly
Insufficient or sporadic tunable oscillator RF output	Defective klystron V109	Replace
	Improper klystron installation	Check and install properly
	Improper klystron repeller tracking voltage	Readjust tracking circuit controls R118, R121, R123 as required
Insufficient or sporadic fixed oscillator RF output	Defective klystron V111	Replace
	Improper klystron installation	Check and install properly
	Improper klystron repeller voltage	Readjust R135
Excessive attenuation	Excessive RF signal input level to HO-A	Establish input level to less than -15 dbm
	Improper diode mixer current during measurement	Establish proper diode mixer current
	Faulty measurement test setup	Arrange setup properly
	Spurious signal input leakage	Eliminate source (see paragraph 4.5.3, step 12)
Improper tunable oscillator frequency relative to dial setting	Dial slipped on shaft	Readjust dial position
	Defective or maladjusted repeller tracking voltage circuit	Check voltage and refer to figure 5.9; readjust controls R118, R121, R123 as required
	Defective klystron V109	Replace
Signal detection at wrong dial setting	Operation at image frequency	Retune to proper setting
	Dial slipped on shaft	Readjust dial position

TABLE 5.3 (Cont'd)

Symptom	Possible Trouble	Suggested Check and/ or Remedy
Improper diode mixer current I_1 or I_2	AFF function maladjusted	Adjust AFF properly
	Insufficient RF output from tunable or fixed oscillator	Measure output with RF power meter; check power supply voltages; replace klstron V109 or V111 as required
	Defective first or second mixer diode	Replace diode assembly as required
	Defective component in HO-A mixer module	Check input VSWR at J1 or J3; check conversion loss; check 3-db bandwidth of multisection cavity; return HO-A to Weinschel for repair.
Excessive incidental FM on Tunable oscillator output	FINE TUNING control improperly adjusted	Readjust to peak
	Excessive AC ripple in power supply	Connect AC millivoltmeter to J103 on front panel to measure AC ripple; replace V103, V104, V107, V108 as required
	Defective klystron V109	Replace
Excessive incidental FM on fixed oscillator output	Excessive AC ripple in power supply	Connect AC millivoltmeter to J104 on front panel to measure AC ripple; replace V103, V104, V107, V108 as required
	Defective Klystron V111	Replace
Excessive oscillator power output level instability	Poor beam voltage power supply regulation	Check power supply regulation; replace V102, V103, V104 as required
	Defective klystron V109 or V111	Replace
Inability to peak tunable oscillator RF output with FINE TUNING control	Repeller tracking function improperly adjusted	Readjust R121, R123 as required
	Tracking control R118 improperly adjusted	Check repeller voltage vs. dial setting; adjust R118

SECTION VI

Model HO-1 Oscillator Module

Electrical Parts List

Symbol	Description	Weinschel Part No.
B101	Blower -	
	Motor, with Capacitor	21-1
	Blower Housing	21-2
	Impeller	21-2-1
C101	Capacitor, electrolytic, 10-10 mfd, 450V	32-11
C102	Capacitor, metalized paper, 1 mfd, 400V	33-5-1
C103	Capacitor, part of B-101	
C104	Capacitor, oil-filled, 1 mfd, 1000V DC	35-6
C105	Capacitor, oil-filled, 1 mfd, 1000V DC	35-6
C106	Capacitor, molded paper, .015 mfd, 200V	33-1-R015
C107	Capacitor, metalized paper, 1 mfd, 400V	33-5-1
C108	Capacitor, molded paper, .1 mfd, 1000V	33-7-R1
C109	Capacitor, molded paper, .1 mfd, 600V	33-3-R1
C110	Capacitor, molded paper, .1 mfd, 1000V	33-7-R1
CR101	Diode, 1N990B	12-80
CR102	Diode, IN990B	12-80
DS101	Pilot lamp assembly	51-4
	Lamp, #47	50-1
DS102	Pilot lamp assembly	51-7
	Lamp, NE 51 H	50-13
F101	Fuse, 3AG, 2A	52-1-2
F102	Fuse, 3AG, 3A	52-1-3

Symbol	Description	Weinschel Part No.
J101	Connector, type N female	63-19
J102	Connector, type N female	63-19
J103	Connector, BNC female	62-55
J104	Connector, BNC female	62-55
J105	Connector, female	63-46
K101	Relay, DPDT, U5V, 5A	47-9
K102	Relay, thermal delay, 117V, 90 sec.	47-8
L101	Choke, filter, 3 hy, 150 ma	40-66
L102	Choke, filter, 8 hy, 100 ma	40-38
P101	Plug, AC, recessed male	62-38
R101	Resistor, comp., 3.3 meg., 10%, 1W	25-2-3R3M
R102	Resistor, wirewound, 25K, 5%, 25W	26-8-25K
R103	Resistor, comp., 120K, 5%, 1W	25-9-120K
R104	Resistor, comp., 68K, 5%, 1/2W	25-8-68K
R105	Potentiometer, carbon, 25KΩ, 2W	20-13
R106	Resistor, comp., 91K, 5%, 1/2W	25-8-91K
R107	Resistor, comp., 1 meg., 10%, 2W	25-3-1M
R108	Resistor, comp., 1 meg, 10%, 2W	25-3-1M
R109	Resistor, comp., 2.2 meg., 10%, 1W	25-2-2R2M
R110	Resistor, comp., 820KΩ, 10%, 1W	25-2-820K
R111	Resistor, comp., 68KΩ, 10%, 1W	25-2-68K

Parts List (Contd.)

Symbol	Description	Weinschel Part No.
R112	Resistor, comp., 68K, 5%, 7W	26-56-68K
R113	Resistor, comp., 82K, 10%, 1/2W	25-1-82K
R114	Potentiometer, carbon, 50KΩ, 2W	20-14
R115	Resistor, comp., 150KΩ, 10%, 1/2W	25-1-150K
R116	Resistor, comp., 680Ω, 10%, 1/2W	25-1-680
R117	Resistor, comp., 680Ω, 10%, 1/2W	25-1-680
R118	Potentiometer, carbon comp., special taper 100KΩ, ±20%, 2W	20-140
R119	Potentiometer, carbon, 10KΩ, 2W	20-12
R120	Resistor, comp., 100KΩ, 10%, 1W	25-2-100K
R121	Potentiometer, carbon, 10KΩ, 2W	20-12
R122	Potentiometer, dual, 10K/50KΩ, 1/2W, linear	20-139
R123	Potentiometer, carbon, 250KΩ, 2W	20-26
R124	Resistor, comp., 10 meg.,10%, 1/2W	25-1-10M
R125	Resistor, comp., 470KΩ, 10%, 1W	25-2-470K
R126	Resistor, comp., 470KΩ, 10%, 2W	25-3-470K
R127	Resistor, comp., 470KΩ, 10%, 2W	25-3-470K
R128	Potentiometer, carbon, 10KΩ, 2W	20-12
R129	Resistor, comp., 100KΩ, 10%, 1W	25-2-100K
R130	Resistor, comp, 10 meg., 10%, 1/2W	25-1-10M
R131	Resistor, comp., 470KΩ, 10%, 1W	25-2-470K
R132	Resistor, comp., 82KΩ, 10%, 1W	25-2-82K
R133	Resistor, comp., 470KΩ, 10%, 2W	25-3-470K
R134	Resistor, comp, 180KΩ, 10%, 2W	25-3-180K
R135	Potentiometer, carbon, 100KΩ, 2W	20-6

Parts List (Contd.)

Symbol	Description	Weinschel Part No.
SW101	Switch, toggle, SPST	55-1
SW102	Switch, toggle, DPDT	55-4
T101	Transformer, Power	B40-105
T102	Transformer, Filament	B40-89
V101	Tube, electron 5U4G	10-78
V102	Tube, electron, 6AS7	10-3
V103	Tube, electron, 6SF7	10-4
V104	Tube, electron, 0C3	10-5
V105	Tube, electron, 5R4GYA	10-10
V106	Tube, electron, 12BH7	10-70
V107	Tube, electron, 6AU6A	10-2
V108	Tube, electron, 0A2	10-17
V109	Tube, electron, 6BL6	10-105
V110	Tube, electron, 6X4	10-64
V111	Tube, electron, 6BL6	10-105
V112	Tube, electron, 6X4	10-64
Z101	Tunable oscillator cavity	C121-758
Z102	Fixed oscillator cavity	C121-712
	Klystron coil spring	A121-246

HO-A Mixer Module

Electrical Parts List

Symbol	Description	Weinschel Part No.
J1	Connector, type N female, part of half-wave reaction cavity, not separately replaceable	
J2	Connector, type N female	A121-825
J3	Connector, type N female, part of 8.5-db coupler, not separately replaceable	
J4	Connector, type N female	B121-846
J5	Connector, type N female, part of 8.5-db coupler, not separately replaceable	
J6	Connector, type N female, part of 10-db coupler, not separately replaceable	
J7	Connector, type N female	B121-852
M1	0-3 ma DC Meter	A121-833
W1	Cable assembly	B121-848-1
W2	Cable assembly	B121-848-2
W3	1F Cable assembly	B121-847
W4	1F Cable assembly	B121-850
	Current Monitor "tee"	B121-743
	Input loop Diode cable assembly - (1st Diode Mixer)	B121-844
	Half wave reaction cavity	C121-721
	10 db directional coupler	1-37
	8.5 db directional coupler	1-38
	Multisection Cavity	D121-795
	2200 mc low pass Filter	1-39
	2090 mc Tuner	B121-728

Symbol	Description	Weinschel Part No.
	2nd Diode Mixer Mount	12-82
	30 mc IF Matching Network	B121-849

WARRANTY

Weinschel Engineering warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warrant is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to make good at our factory any part or parts thereof (except tubes, transistors, fuses, or batteries) which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which on our examination shall disclose to our satisfaction to have been defective.

Weinschel Engineering reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of Weinschel Engineering.

Weinschel Engineering neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale of its instruments and equipment.